POWER

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Engineer or Engineman?

WHICH are you employing? Do you look upon him as a "hand" or a head; as a laborer or as the head of a department?

If you were going to reorganize your power department — his department — would you call him in and get his ideas about it or would you get the ideas of fellow manufacturers and then hire an outsider to carry them out?

If you had an engineer and knew it, you would at least advise with him. It would do no harm to try it anyway even if he had not seemed to scintillate with suggestion. There is often a lot of engineering sense and experience, of knowledge of new developments and a practical sense of their limitations and possibilities locked up in an undemonstrative and unpretentious operating engineer.

But you who are running the power plant — how seriously do you take it? Is it for you just a meal ticket or your life's interest?

Do you invite and encourage the boss to talk with you about your work; to recognize the power producing and distributing part of the business as your department?

Do you try to have something agreeable and encouraging to tell him when you have a chance, and not always meet him with a kick about something that needs fixing or a touch for money that should be spent?

Do you try to make it pleasant and worth while for him to look in at the engine room or stop you in passing, so that he does not avoid you as a trouble spot?

And if he should call you in consultation about a contemplated change, are you all set to tell him what his power and lighting and heating and process steam is costing now and how and at what expense for reorganization the process could be cheapened or improved?

Are you his engineer, or has he got to call in somebody?

F. R. Low

Selecting Equipment for Western Avenue Pumping Station

A BRIEF summary of certain comparative studies made in selecting the pumping units, the number and size of boilers, the fuel-burning equipment and evaporators over softeners for the makeup. Steam turbine geared centrifugal pumps showed the lowest over-all operating economy, and underfeed stokers were selected in preference to powered coal or oil.

BY LORAN D. GAYTON*

THE economic design of modern municipal pumping stations is affected by such a large number of factors that the engineer responsible is called upon to solve a multiplicity of problems. Naturally, the hydraulic part of the problem looms large, but of equal importance in respect to first cost and operating expense is the design of the mechanical and structural elements entering into a utility of this kind. It always must be kept in mind that reliability of operation is the controlling factor to which all other items must be subordinated, but as a rule it will be found that the most reliable design is also the most economical.

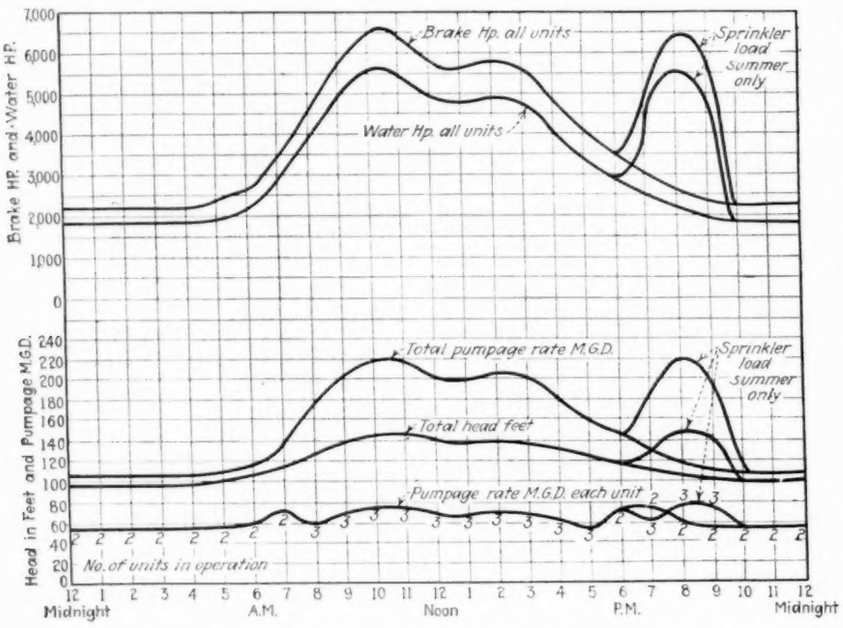

Fig. 1—Pumpage, head and power curves

The present article will be limited to some of the studies and comparisons made when selecting the mechanical equipment for the new pumping station at Western Avenue and Fiftieth Street, Chicago. Briefly, this will be a steam station having an installed pumping capacity of 300,000,000 gal. per day. The main pumps will be of the centrifugal type, driven through gears by compound steam turbines operating on steam at 300 lb. gage pressure and 200 deg. F. superheat. Construction of the building is now in progress, and it is expected that the station will be ready for service during 1927.

One of the first things to be done was to decide upon the type of pump and prime mover that would give the best results. Preliminary designs and estimates were made to study and compare the following types of equipment: Steam-turbine-geared centrifugal pumps, vertical, triple-expansion pumping engines, Diesel-engine-driven centrifugal pumps and electric-motor-driven centrifugal pumps. The data in Table I, based on assumed conditions of load and head, give a summary of the results of this study, including comparative figures on operating economy, original investment, operating costs per year and unit costs.

Triple-Expansion Pumping Engine—Reference to this table will show that the triple-expansion pumping engine is by far the most efficient mechanically, and most economical in steam consumption, as indicated by a duty of 205,000,000 ft.-lb. per 1,000 lb. of steam at 200 lb. gage pressure and 100 deg. F. superheat. The coal consumption, therefore, would be lower than for any other steam unit, so that the boiler plant could be made somewhat smaller. On the other hand, the maximum size for this type of unit is 50 million gallons per day so that it would have required for the assumed load six triple-expansion engines to do the work of four turbo-centrifugals, and the initial cost would have been considerably higher. The table shows that the building for the engines costs more than for the turbo-centrifugals; the labor cost is higher; there is trouble in using the condensate, owing to the oil contained in it, and it is more difficult to follow the load curve than with a turbo-centrifugal pump. Owing to these various factors the cost of operation of the triple-expansion station is about 14 per cent higher than of a turbo-centrifugal station.

Diesel Oil Engine—Of this type of equipment the original cost is high, about $500,000 more than for a steam-turbine station. The fuel cost is about the same as for the steam turbine plant, but the building and labor costs are less. In the final analysis it will be seen that the unit cost of pumping 1,000,000 gal. one foot high is about the same as for the steam-turbine station.

Regardless of any consideration of operating cost, there are mechanical difficulties in the design of a Diesel pumping plant that would be prohibitive in a station like the one at Western Avenue. Engines of the required horsepower operate at about 120 r.p.m. To develop 150 ft. head at 120 r.p.m. would require four-stage centrifugal pumps with impellers about 11 ft. in diameter. Pumps of this size would be an experi-

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ment and their efficiency would be problematical. The installation of gears would further increase the first cost.

Electric-Motor-Driven Centrifugal Pumps—This type of station requires less land, less building, less equipment and less labor than any other, and the entire original investment is about 40 per cent of that of the steam-turbine station. In the present case the cost of the electrical energy was the controlling factor, and this brought the total operating cost of the electric station (with constant-speed induction motors) to about 10 per cent above the operating cost of the steam-turbine station.

In this connection it is safe to say that for large pumping stations of 200 m.g.d. and over, and operating against comparatively high heads, the steam-turbine, geared, centrifugal pump will show the lowest over-all operating cost, when all the factors entering into this cost are considered.

TABLE I—COMPARATIVE ESTIMATED COSTS OF COMPLETE STATION

Costs based on 300 million gallons per day for 300 days per year (which is equal to 90,000 million gallons per year) against a total head of 150 feet.

	Type of Prime Mover	Steam Turbine Steam Press., 300 lb. Superheat, 200 deg. F. Abs. Back Pres., 1 Lb.	Triple Expansion Eng. Steam Press., 200 lb. Superheat, 100 deg. F. Abs. Back Press., 2 Lb.	Diesel Oil Engine 6 Cylinder, 2 Cycle	Electric Motor 2,300 Volts	Electric Motor 12,000 Volts
General Data	Type of pump	Centrifugal single-stage	Plunger pump	Centrifugal 4-stage	Centrifugal single-stage	Centrifugal single-stage
	Capacity of pump, million gallons daily	60	50	60	60	60
	Water horsepower of pump	1,590	1,315	1,590	1,590	1,590
	Engine horsepower	1,900 brake	1,390 Indicated	1,900 brake	1,900 brake	1,900 brake
	Mechanical effect of unit, per cent	Pump, 83½	94½	Pump, 83½	Pump, 83½ Motor, 94	Pump, 83½ Motor, 94
	Actual thermal efficiency of unit, per cent	18	21.8	23.7	.....	.....
	Steam or oil consumption, lb. per water horsepower hour.	11.45	9.66	0.565	.....	.....
	Steam or oil consumption, lb. per engine horsepower hour.	9.55 per brake hp.	9.15 per i. hp.	0.473 per brake hp.	.....	.....
	Electric power consumption, kw.-hr. per million ft.-gal.	.....	.....	.....	4.75	4.655
	Boiler horsepower required	4,060 5 units in operation	3,200 6 units in operation	.....	.....	.....
	Duty—million ft.-lb. of work per 1,000 lb. steam	173	205	.....	.....	.....
	Duty—million ft.-lb. of work per million B.t.u.	130	162.8	184	.....	.....
	Fuel or power for 300 days	61,200 tons of coal 5 units in operation	48,240 tons of coal 6 units in operation	4,752,000 gal. fuel oil 5 units in operation	64,125,000 kw.-hr. 5 units in operation	62,842,500 kw.-hr. 5 units in operation
Original Investment	Cost of land	$52,072	$58,748	$32,550	$23,400	$20,900
	Cost of buildings	933,350	1,154,250	656,800	455,000	420,000
	Cost of equipment	1,201,400	2,423,858	1,716,495	352,500	342,900
	Miscellaneous	18,000	20,000	66,000 fuel oil tank	20,000	20,000
	Total investment	$2,204,822	$3,656,856	$2,471,845	$850,000	$803,800
Operating Costs per Year	Cost of labor	$63,495	$89,437	$30,000	$25,680	$25,680
	Cost of fuel—Coal $4 per ton—oil $0.05 per gal.	244,800	190,944	237,600	.....	.....
	Cost of power $0.0064 per kw.-hr	.....	.....	.....	413,904	408,132
	Cost of oil, waste, etc	3,000	15,300	20,000	5,000	4,000
	Repairs and maintenance	22,624	40,616	13,700	5,280	5,144
	Interest on investment and depreciation	136,600	201,700	179,385	69,200	65,735
	Total operating cost	$470,519	$537,997	$480,685	$519,064	$508,691
Unit Costs Per Million Gal.	Labor	$0.71	$1.00	$0.33	$0.285	$0.285
	Fuel or power	2.72	2.12	2.64	4.60	4.535
	Oil, waste, etc	0.03	0.17	0.22	0.056	0.044
	Repairs and maintenance	0.25	0.45	0.15	0.06	0.057
	Interest on investment and depreciation	1.52	2.24	2.00	0.77	0.73
	Total cost of pumping	$5.23	$5.98	$5.34	$5.77	$5.65
	Total cost of pumping one million gallons one foot high	$0.0349	$0.04	$0.0356	$0.0385	$0.0377

Compound Turbines Prove Desirable

The foregoing comparisons were made on the definite assumptions of pumpage and head given in the table before any attempt had been made to work out definitely a daily load curve. When developed as in Fig. 1, the curves give heads ranging from 98 to 145 ft. and total pumpage varying from a 100 m.g.d. rate during the night to a rate of 217 m.g.d. during the day. On this basis it was found that three pumps, instead of the five given in the table, having a capacity range of from 50 to 75 m.g.d. and a total head range of from 105 to 150 ft., would give ideal operating conditions. A fourth unit was added for reserve. The probabilities are that there never will be more than three pumps operating and never less than two, as indicated in the lower curve of Fig. 1. As the units selected have high overload capacity, two units can carry the average load if for any reason two pumps should be out of commission.

Bids were received on steam-turbine-geared units of the foregoing capacity, three of them involving single-barrel turbines and the other a compound turbine. The compound units were highest in first cost but lowest in steam consumption, and as they required less floor space than the single-barrel units, it was possible to reduce the building cost by $84,000. When the four bids were evaluated as to operating cost, the compound-turbine proposal was the lowest received. These units have a guaranteed water rate of 9.5 lb. per water-horsepower per hour and at the most efficient point a duty of 208,000,000 ft.-lb. per 1,000 lb. of steam at 300 lb. pressure and 200 deg. F. superheat.

Gears of the double helical type were selected. Both the main and the circulating pumps are of the single-stage, double-suction, horizontally split casing, single-inclosed-impeller type, with suction vertically downward and the discharge horizontal. Under maximum operating conditions, the speed of the pump will not exceed 600 r.p.m. In the condenser, which is of the surface type, provision is made for not less than one square foot of tube surface for each five pounds of steam consumed per hour by the main unit and all its auxiliaries.

With each condenser there will be two steam ejector air pumps of the two-stage type, each having sufficient capacity to handle the air leakage under maximum operating conditions. The air pump will be provided with surface type inter- and after-condensers. The condensate pumps also will be in duplicate, one unit to be driven by a water motor and the other by an electric motor, the water-motor driven unit to be used under normal operating conditions. The electric motor will be a variable-speed direct-current machine and it will be used when necessary for starting and stand-by purposes.

After the main pumping equipment had been selected

and the steam requirements calculated, studies were made of the different types of steam boilers, combustion equipment, piping, etc. Mechanical stokers, powdered coal and oil-fired boilers were considered.

An investigation made by the writer a few years ago indicated that for a boiler installation of about 40,000 sq.ft. of surface, the steam could be generated by stokers at about the same cost as by powdered coal. At that time the danger from dust explosions was considered too great a hazard to be considered for a municipal water pumping plant where absolute reliability is the prime factor. Since then the unit-type pulverizer has been developed for small plants to a point where it should be seriously considered.

The relative cost of oil and coal in any particular locality will decide which of these fuels should be used. In a city where oil is low in price and coal high, the former generally is more economical, but in Chicago where bituminous screenings now cost $2.90 a ton by rail delivery and oil 5c. per gallon, after taking into consideration the relative boiler efficiencies, the cost of steam from fuel oil is approximately double the cost from coal. Another factor to give consideration is that the price of oil fluctuates, whereas the price of coal has been comparatively uniform for many years. In this respect Fig. 2 gives an interesting comparison.

Selection of Boilers

Tabulation of steam loads for each hour of the day for both the main and auxiliary units gave clear insight into the demands upon the boiler plant. It was realized that if the highest economy was to be obtained, the

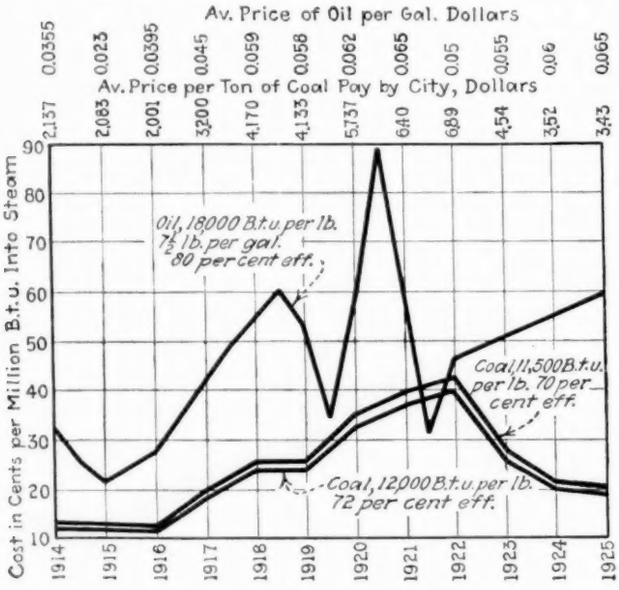


Fig. 2—Coal vs. oil as boiler fuel

boilers must operate at or near their most efficient point for the greater part of the time. They must be of such size and number that when a boiler is taken off the line, the others will not be forced to too high a rating, and when a boiler is put on the line, the rate of operation will not be too low for good efficiency. At the same time sufficient reserve capacity must be provided and the number of hours during which the fires are banked held to a minimum. If economy of operation is being sought, it is well to limit the boiler range between 100 and 200 per cent of rating, the highest efficiency being obtained generally between 125 and 150 per cent.

To decide upon the size and number of boilers for the Western Avenue Pumping Station, the comparison indicated in Table II and Fig. 3 was made and the results may be taken as typical for any station. This study showed that if 6,000-sq.ft. boilers were selected, the peak loads could be carried on three boilers, with one

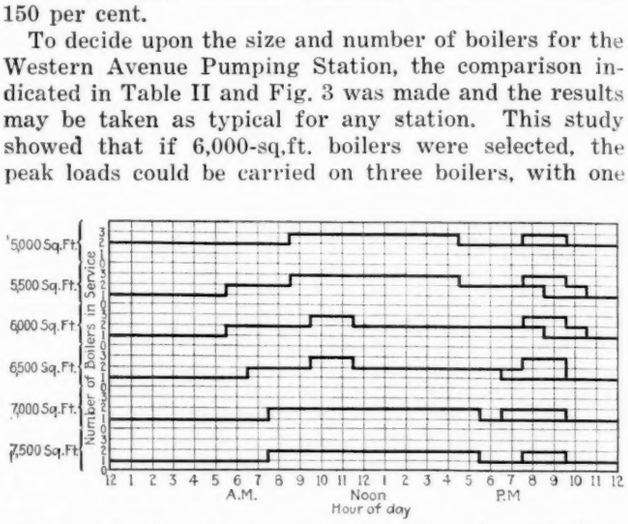

5,000 Sq.Ft.
5,500 Sq.Ft.
6,000 Sq.Ft.
6,500 Sq.Ft.
7,000 Sq.Ft.
7,500 Sq.Ft.
Number of Boilers in Service
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
A.M. Noon P.M
Hour of day

Fig. 3—Study made to arrive at proper size of boilers

and two units on the line for the remaining hours of the day. In an emergency the peak load could be carried on two boilers by running them at slightly over 200 per cent of rating.

If smaller boilers should be installed, it would not be possible to carry the peak load on the two boilers at the assumed maximum rating of 200 per cent and the installation of the 6,500-sq.ft. boilers would increase the number of banked hours, enlarge the investment and reduce the flexibility of the plant. By installing the four 6,000-sq.ft. boilers, high average efficiency, proper reserve capacity and a flexible boiler plant were secured. The maximum demand for steam will be about 75,000 lb. per hour, and this will be generated at 315 lb. gage pressure and 225 deg. F. superheat.

Boiler Auxiliaries

In selecting the auxiliary equipment, the type of stoker, for example, will depend primarily upon the coal that is to be used, and the size of the stokers, fans and other equipment will depend upon the rating at which the boilers will be operated and the fluctuations in the load. This equipment consumes considerable power, and it must be so designed that it will operate at the most efficient point the greater part of the time and always be flexible enough to meet the fluctuating demands and large enough to carry the emergency overloads. As a consequence the relation of these auxiliaries to the main equipment must be studied carefully.

Investigation made by the writer in the past indicates that where the average boiler rating is not above 150 per cent, it is not economical to install economizers, but that an increase of boiler economy can be shown by the use of certain types of air preheater.

It will be of interest to add that the study of auxiliaries resulted in the selection of underfeed stokers and turbovane fans to supply forced draft. Each stoker will have individual air ducts so that there will be no chance for lost pressure through cross-connections.

Three different methods of driving the auxiliaries were considered—all motor drive, all steam drive, and a combination of the two. It was found that a plan wherein practically all the auxiliaries were driven by

electric motors supplied by either one of two direct-current generating units, driven by non-condensing steam turbines, adapted itself to the station heat balance and therefore gave the greatest economy. Stokers, fans, boilers, feed pumps, etc., will be driven by direct-current motors. For protection there will be one turbine-driven boiler-feed pump in addition to the two motor-driven pumps, any one of the three having sufficient capacity to supply the demand.

Practically all the auxiliaries will be installed in a separate room between the boiler and pump rooms. Indicating and recording instruments will be placed in this room so that one man will have the entire steam generating operation under his control.

Feed-Water System

In the study of the feed-water system some interesting facts were developed which will apply equally well to other stations. The following description of the system adopted will give a general idea of the items to be considered and the comparisons that should be made. The desire for high boiler efficiency led to the use of an evaporator plant for distilling all makeup water to be supplied to the boilers. The small amount of makeup required justified the investment in a small evaporator.

Aside from the evaporator plant and the high pressure required from the boiler-feed pumps, the feed-water system is not unusual. Broadly speaking, all the steam leaving the boilers is returned in the form of condensation, the only makeup required being that to replace loss from the system through vents, drains, safety valves and relief valves. The quantity of loss is not expected to be more than 3 per cent of the total output of the boilers, although the evaporators will have capacity to provide 7½ per cent makeup if necessary.

A factor of vital importance in the feed-water system is the absence of oil in the condensate and exhaust steam. This desirable condition may be credited to the use of steam-turbine-driven pumps and turbine- and motor-driven auxiliary equipment.

The logical place to start tracing the feed-water system seems to be at the raw makeup water connection to a small open feed-water heater. This heater or evaporator preheater as it is called, serves three important purposes. In the first place, gases in the makeup water are removed almost completely and the condition of the water improved by the heating it receives from the exhaust steam. Secondly, as it is heated to 210 or 212 deg. a considerable load is taken off the evaporator plant, allowing smaller units than otherwise would have been possible. The preheater also provides storage to take care of the small fluctuations in demand and a place for the filtering off of any solids that may be contained in the raw water.

The evaporator proper, which will be of the two-effect high-pressure type, will be so piped that it may be operated with either unit as a single-effect plant, but in normal operation this of course would not be done. By the use of the double-effect, a lower heat head is established in the evaporator unit, allowing evaporation to take place without danger of priming.

The heated makeup water is pumped into the shells of both effects through float-controlled regulating valves. The coils of the first effect are furnished with live steam somewhat reduced in pressure. The makeup water, being further heated by the steam coils, is vaporized and passes over into the coils of the second effect at a pressure and temperature considerably lower than the original steam supply.

Within the second effect the action is the same as in the first, with the exception that the vapor from the first serves as the heating medium of the second, and the final vapor formed is lower in pressure and temperature.

In the station under consideration the final pressure is expected to range between 15 and 25 lb., and at this pressure the vapor is passed on to a small surface condenser, through which the boiler feed water is passed as circulating water. This provides an opportunity for raising the temperature of the boiler feed higher than could be done in the usual open heater.

Condensate from the steam coils and vapor condenser is trapped and returned to the feed-water heater, so that the evaporator operates without heat loss, except for slight radiation from the surfaces and a blowdown once a day.

The main supply of boiler-feed water is heated in either one of two duplicate open feed-water heaters supplied with exhaust steam from the turbo-generator delivering auxiliary power. Should the exhaust be insufficient to maintain the feed-water temperature at or near 212 deg. F., steam may be bled from one of the main turbines to make up the deficiency. All of the main turbines are provided with bleeder outlets for this purpose, although in actual operation, probably only one will be floated on the heater line, because of the comparatively small quantity of bleeder steam that will be needed.

TABLE II.—SUMMARY OF BOILER COMPARISONS

Boiler surface, sq.ft.	5,000	5,500	6,000	6,500	7,000	7,500
No. of boilers installed	4	4	4	4	4	4
Max. number boilers in operation at one time	3	3	3	3	2	2
Per cent rating at which boilers are operated	99–169	104–184	95–180	105–175	100–194	103–187
Per cent rating at which boilers must be operated to carry peak with 2 boilers	237	216	198	183	170	159
Boiler-hours in operation—365 days	20,805	17,885	15,320	14,782	12,957	12,775
Per cent of boiler hours banked—365 days	20.8	32	40.3	43.8	36.1	27.1
Original cost of installing boilers, settings, stokers, fans and ducts	$80,000	$102,000	$118,000	$127,000	$135,000	$142,000
Interest on investment at 4 per cent depreciation at 3½ per cent repairs and maintenance	$11,300	$13,450	$15,160	$16,360	$17,500	$18,550
Total cost of coal at $5 per ton—365 days	$145,000	$147,000	$149,000	$150,000	$145,000	$145,500
Total cost of operation—365 days (coal and fixed charges)	$156,300	$160,450	$164,160	$166,360	$162,500	$164,050
Total cost of 1,000 lb. steam (coal and fixed charges)	$0.397	$0.407	$0.415	$0.422	$0.413	$0.416

Assumptions: Coal, heat value, B.t.u. per lb. 11500; steam pressure at boiler, lb. gage, 315; Superheat at boiler, deg. F., 225; factor of evaporation, 1.19; steam pressure at turbine, lb. gage, 300; superheat at turbine, deg. F., 200.

The heaters are to be of the conventional tray type. They will supply by gravity the boiler feed pumps which are placed on the floor beneath them. These pumps are rather unusual in that they will be small-capacity centrifugals pumping against a head of over 800 ft. The motor-driven pumps will require eight stages, arranged as four-stage pumps in series with the motor placed between the two pumps. Each of the three feed pumps will have a capacity of 200 gal. per min. As previously mentioned, the discharge from these pumps passes through the vapor condenser, where it picks up a few degrees of temperature and passes on into a loop header feeding the boilers.

Another point in connection with the feed-water

system that should be mentioned is the provision for storage of distilled water. Two tanks for this purpose are placed in the basement of the auxiliary room, with a total capacity to fill an empty boiler without interfering with the feed process to the other boilers. One of these tanks is floated continuously on the main condensate line and will be kept filled from that source, rather than attempting to store the hot returns from the evaporator. The contents of this tank will be pumped automatically to the feed-water heater at times of low water.

As a method of treating the makeup water, softeners were considered and a study made comparing the costs and the relative advantages of the two systems. The softener plant would have consisted of two tanks with salt pots, and a filter placed in the line preceding the softeners. The first cost of this equipment would have been only one-third of the cost of the evaporator plant, which, in a great number of cases, is a big factor. The softener is effective in preventing the formation of boiler scale, requires little space and attention, and in many instances gives entire satisfaction. With such an installation it would have been necessary to blow down the boilers as it is done in other pumping stations of the city; that is, one gage at the beginning of each eight-hour shift. This is an expense that can be charged against the softening system, as the boiler blowdown practically will be eliminated by the use of the evaporators. Other charges that can be placed against the softener system are, salt for regeneration and fixed charges on the equipment. Maintenance and labor were considered the same for either system.

The evaporator plant may be charged with radiation losses from the equipment, vapor losses from the preheater and evaporator blowdown, all of which are small compared to the boiler blowdown necessary with the water softener. Fixed charges were figured at the same percentage as for the softener.

Calculations carefully made showed a net annual saving of about $500 for the evaporator plant over the softener. This amounted to a net earning of 12.8 per cent on the added investment of $4,000 required by the evaporator plant.

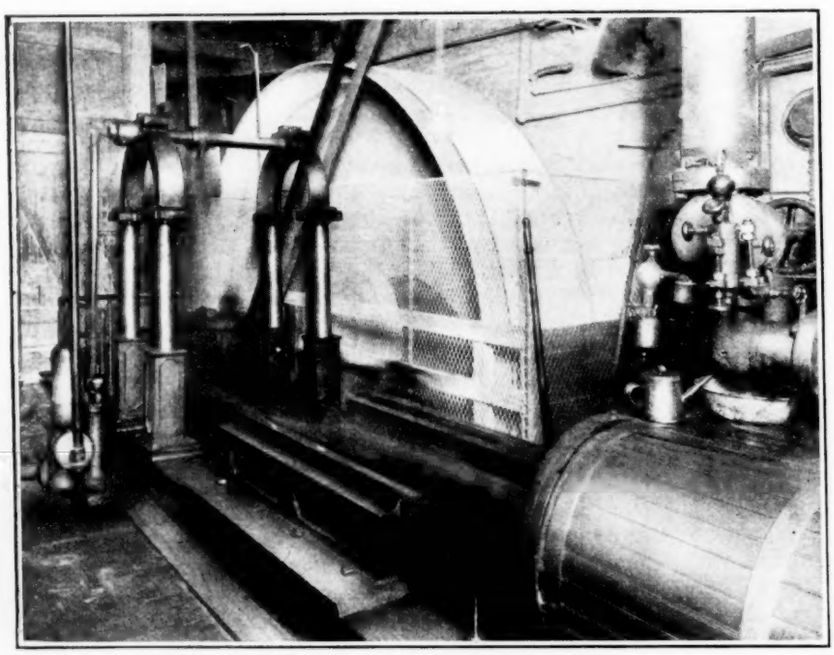
Reasons for recommending the evaporator plant for this station are summed up in the following: It gives distilled water, which is a guarantee of clean boilers and clean feed to the turbines and other equipment. It adapts itself to the balance of the station, eliminates boiler blowdown, alleviates the danger of corrosion due to gas in the boiler-feed water, requires little attention, and despite its higher first cost, shows an annual earning on the added investment.

Steam Piping Selected on Basis of Investment Returns

With high-temperature steam the piping forms a considerable part of the total cost of the plant, and it is, therefore, important from the viewpoint of economy, that this item be carefully considered. The pressure drop, due to friction, the radiation loss, and the initial cost must be considered in arriving at the most economical size. Different combinations in which the boilers and prime movers may operate should be studied, in order that the runs may be as short as possible and all necessary bends and valves may be eliminated. A careful analysis of all piping layouts will show worth-while returns in investment saved. A complete set of piping charts has been worked out and will be presented in a later issue.

The foregoing does not purport to be any complete text on the economical design of large municipal pumping stations, but was written in order to call attention to the many and varied problems that must be solved and to show that the energy and time required for a careful and full analysis of such projects will show large returns in lower initial investment and operating costs.

All design and construction work in connection with the new station has been done under the general direction of John Ericson, city engineer, with the writer in charge of design and J. J. Versluis, engineer of water works construction.



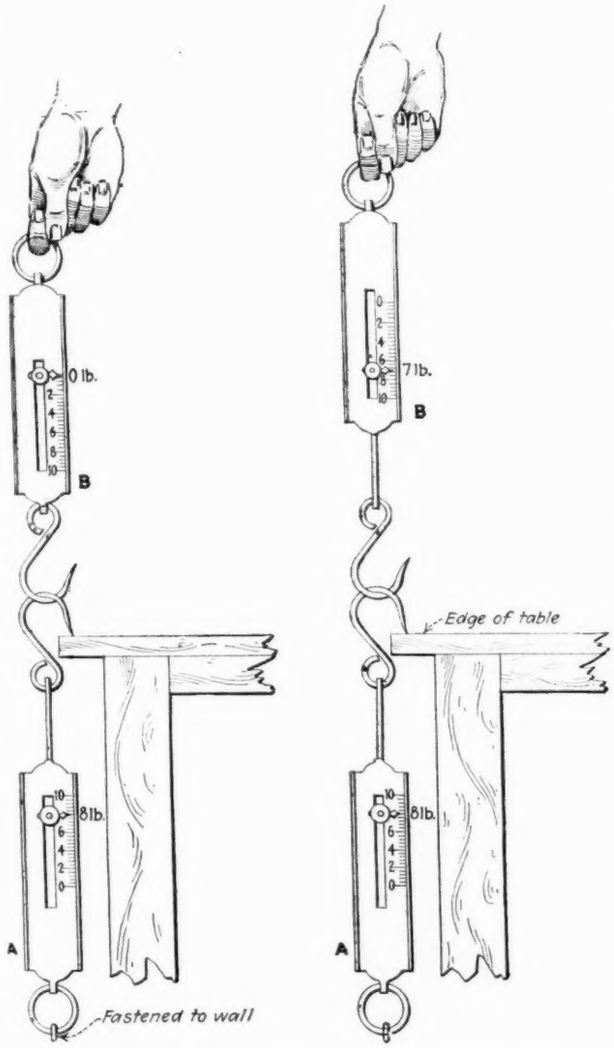
Plugging Along Since 1855

This 100-*hp. engine, installed in* 1855, *is still grinding paint for Samuel H. French & Co., on the corner of York Road and Callowhill Street, Philadelphia. The engine is* 20 *in.* x 36 *in. with slide valve and a* 15-*ft. main driving pulley running at* 40 *r.p.m.* (*originally* 30 *r.p.m.*) *Aside from the renewal of the cylinder* 40 *years ago, the engine is as originally installed. Two double leather belts, one* 33-*in. wide running from the main pulley to a jackshaft and another* 24-*in. wide from the jackshaft above have operated for the full seventy-one years life of the engine.*

Information supplied by the Leather Belting Exchange.

Effect of Steam Pressure on Bolt Tension —A Simple Demonstration

Discussing the effect of steam pressure upon the tension in cylinder-head bolts, an article in the "What Happens and Why" section of the March 30 issue worked out the problem for two hypothetical cases. In one of these the bolts were assumed to be extremely flexible in comparison with the gasket. For this case it was shown by analogy that turning on the steam pressure would not increase the tension in the bolt, as long as this pressure did not reach the point where the cylinder head would be lifted from the cylinder.



Pulling on upper scale does not increase pull on lower scale

A reader, Charles H. Smith, of Stanford University, California, suggests that this case may be neatly demonstrated by a simple experiment with spring scales. In the arrangement shown in the accompanying sketches, scale *A* represents the flexible bolt. The rigid table top represents the incompressible gasket, and *B* is another scale to represent the action of the steam pressure on one bolt. At the start, as indicated in the left-hand sketch, the lower scale is pulled down until the "bolt" tension registers 8 lb. To make the comparison more vivid, this may be assumed to correspond to 800-lb. bolt tension. The ring of the lower scale is clamped to hold the scale in this position.

While the hook of the upper scale engages with that of the lower, no tension is supposed to be exerted on the former at the start. It is then evident that the left-hand sketch corresponds to the cylinder with the bolt tightened up to the initial tension, but with no steam pressure. Now suppose that a steam pressure is applied equivalent to 700 lb. on each bolt. This condition can be represented by pulling on the upper scale *B* until it registers 7 lb. Scale *A* will continue to read 8 lb., as before, since it is obviously impossible for it to change its reading as long as the hook is not raised from the table.

This demonstrates clearly that for a flexible bolt and an absolutely rigid gasket (a condition that can only be approximated in an actual engine) increase in steam pressure can have no effect whatever on the tension in the bolt up to the point where the cylinder head is lifted from the gasket.

To see what happens in the latter case, continue pulling on the upper scale *B* until the tension there registered exceeds 8 lb. The "bolt" will then be stretched; that is, the hook of the lower scale will be lifted from the table, and the tension in *A* will increase until it equals that registered by *B*.

If a platform scale is substituted for the table top ("gasket"), readings of the "gasket" reaction for any "steam" pressure may be approximately determined, as the platform of the scale will move only slightly. It is evident that in the case illustrated by the left-hand sketch the "bolt" presses down on the "gasket" with a force of 800 lb., while this pressure is reduced to 100 lb. in the right-hand sketch.

THE FOLLOWING VALUABLE FORMULA is not new, but is still unfamiliar to many engineers who might profitably use it:

$$PV = \frac{10.7\,WT}{m}$$

This relation applies to any gas and gives the relation between:

P = Absolute pressure, pounds per square inch
V = Volume, cubic feet
W = Weight, pounds
T = Absolute temperature = deg. F. + 460
m = Molecular weight.

Thus to get the weight of 10.3 cu.ft. of CO_2 ($m = 44$) at 180 deg. F. and 14 lb. absolute pressure it is only necessary to write:

$$(14)\,(10.3) = \frac{(10.7)\,W\,(180 + 460)}{44}$$

or

$$W = \frac{(14)\,(10.3)\,(44)}{(10.7)\,(640)} = 0.926\ lb.$$

A principle to be observed in all oxyacetylene welding operations is never to direct the torch flame upon the welding rod to melt it. The flame should be directed against the joint so as to form a puddle of molten metal. The welding rod should be melted by the heat of the puddle and the radiation from the torch flame. By always forming a puddle in the V and adding to it from the welding rod, using the heat of the puddle to melt the rod, the welding operator is reasonably sure of obtaining penetration and cohesion.

Keeping Insulation in Good Condition on Electrical Machines

By Clair L. Keene*

THE CONDITION of the insulation of an insured machine is unquestionably very important to the insurance engineer, as the greater part of the losses on electrical machinery incurred by insurance companies is a result of insulation failure. A good insulation for electrical machines must have dielectric strength and high electrical resistance, should be tough and flexible and should not be affected by heat, vibration or other operating conditions.

The dielectric strength is usually determined by making a high-potential test, using two times the normal voltage plus 1,000 volts. Dielectric tests are intended to detect weak spots in the insulation and to determine its strength against breakdown under static strain. In low-voltage machines the static strains are so small as to to be almost negligible, but in high-voltage equipment they become very important. Nearly all machines are given a high-voltage test after installation or after major repairs have been made.

Defective Insulation May Cause Current Leakage

Defective insulation may allow a small leakage current to flow. By a local rise in temperature or electrolytic action, the resistance decreases, allowing still more current to flow. This flow of current will be accompanied by a slight charring, which further decreases the insulation resistance and still more current flows. This action is cumulative and eventually a breakdown or a burnout will occur. Leakage of current through insulation may be due to moisture, dirt, oil or other transient operating conditions. It may result when the insulation has become baked or charred due to long-continued overheating from insufficient ventilation or overload.

Oil deteriorates insulation rapidly, and care should be exercised to prevent oil from leaky bearings and external sources from reaching the windings. Failure of insulation resulting in grounds and short-circuits is more frequently traceable to inattention and neglect of proper cleaning of the unit. A machine should be subjected to a thorough cleaning once each week if possible. Windings should be blown out often with compressed air, care being taken that the pressure is not too great and that the air is free of oil and moisture. Collections of dirt and lint saturated with oil or grease should be removed with kerosene or gasoline. Creepage surfaces, exposed end windings and pockets where dirt may collect should be given a coat of insulating varnish, applied after a thorough cleaning, at least once each year and oftener when exposed to moisture. Insulation that has lost its life and has become porous or baked should be carefully cleaned and given one or two coats of insulating varnish. Damaged insulation, small cuts or breaks should immediately be sealed with insulating varnish and taped.

According to the A.I.E.E. Standardization Rules the insulation resistance in megohms, at normal operating temperatures, should be equal to the rated voltage at the terminals divided by the rated capacity in kva. plus 1,000. Insulation resistance is subject to wide variation depending upon temperature, humidity and cleanliness of the machine. However, it gives a good indication as to whether a machine is in good operating condition. Insulation is usually measured with a megger or a similar device. This instrument should be used before a high-potential test for dielectric strength is made, as grounds are sometimes caused by the application of high voltage before the machine has been cleaned of the accumulations of dirt and copper or carbon dust. It should be repeated after the high-potential test to determine if the insulation has been permanently weakened by the application of high voltage.

*Field Engineer, Columbia Casualty Co., New York City

Automatic Regulation of a Small Boiler Plant

By Eric Therkelsen*

IN THE small stoker-fired plant of one or two boilers, in which but one fireman is required per shift, the work leaves plenty of time for watching the drafts, stoker speeds and boiler pressure closely enough to meet

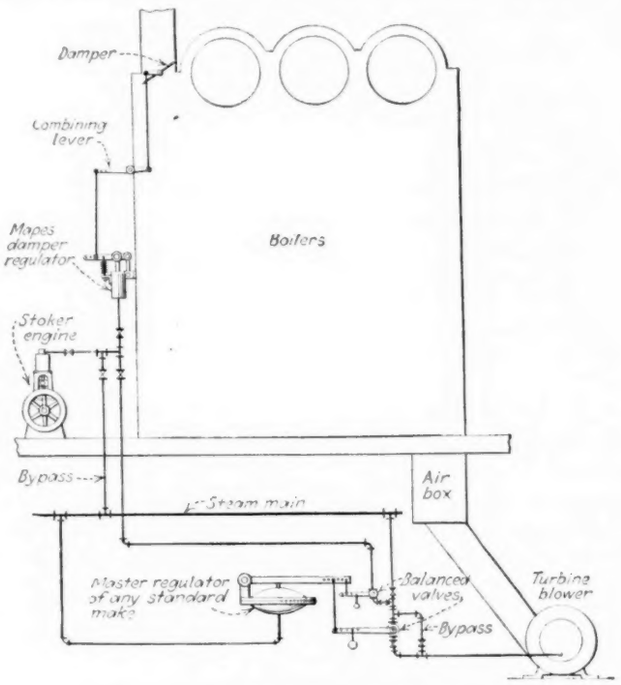


Fig. 1—Sketch showing arrangement of regulating equipment

the standards of efficiency usually prevailing in such plants. The labor saving would be nothing and the coal saving hardly great enough to justify the heavy investment necessary if automatic control were employed with the usual type of apparatus on the market. However, conditions in these small plants could be much improved if they could afford better regulation.

This article describes how one plant solved the problem of automatic regulation and achieved two important results as follows: First, increased the average economy from 5½ to 6½ lb. equivalent evaporation per pound of coal fired and, second, gave the fireman time to keep the plant clean and in perfect repair and make him

*Associate professor of mechanical engineering, Montana State College.

ready for any emergency—all at a total cost of about $40. The coal used is sub-bituminous of about 9,600 B.t.u. per lb. as fired.

This is the heating plant of Montana State College at Bozeman. It heats seventeen buildings, having a total radiation of 50,000 sq.ft., besides supplying steam for laboratories, swimming pool and water heating. Each building has a single temperature regulator which turns the steam on or off the entire building. This produces very sudden changes in load on the boilers. The two 3,750-sq.ft. Stirling-type boilers are fired with traveling-grate stokers. Only one boiler is in service at a time. Space is provided for two additional units.

The original installation controlled the fan speed from the boiler pressure by means of a diaphragm regulator operating a balanced throttle valve on the turbine driving the fan. Two difficulties were experienced with this arrangement. First, the stoker engine would continue to run at the same speed regardless of the fan speed, with the result that unburned coal would be carried over to the ashpit, or else holes would develop in the fire. Secondly, the damper would be open too wide or not wide enough, causing too great or too little draft above the fire. It required constant attention on the part of the fireman to keep the safety valve from popping or the pressure from falling.

Fig. 1 shows how the automatic regulation was rigged up. Steam for the stoker engine was taken from the auxiliary main near the blower turbine and was regulated by means of a small balanced valve operated by the same movement of the regulator chain that controls the blower turbine, thus synchronizing the stoker engine and the blower. Of course the governor on the stoker engine and the belt on the cone pulleys, as well as the tuyere pressures and thickness of fire, must be adjusted occasionally to fit the average load. It is necessary to adjust also the general position of the damper by means of holes in the levers and rods. This is done two or three times a day to suit the average load.

The damper is regulated—that is, opened as the fan speeds up and closed as it slows down—by means of a simple plunger made of a boiler inspector's hand pump with a piston 1¼ in. in diameter. This is connected directly to the steam line supplying the stoker engine. The cylinder and the pipe leading to it from the steam line are filled with oil to prevent leakage. The sketch does not show a horizontal run of pipe from the stoker steam main to the regulator. This traps the oil and water.

Feed water also is automatically controlled. The net result of the change may be judged by the boiler pressure charts Fig. 2, one taken with the hand regulation and the other with automatic regulation of stoker and damper. Note how much more constant the pressure is with automatic regulation. The draft above the fire varies only about 0.04 in. of water from full to low speed of fan. The safety valve is never known to pop unless the steam delivery is shut off in case of trouble, whereas it formerly popped 10 to 15 times a day. Many flue-gas analyses have been made before and after, the average CO_2 increasing from 9 to 10 per cent.

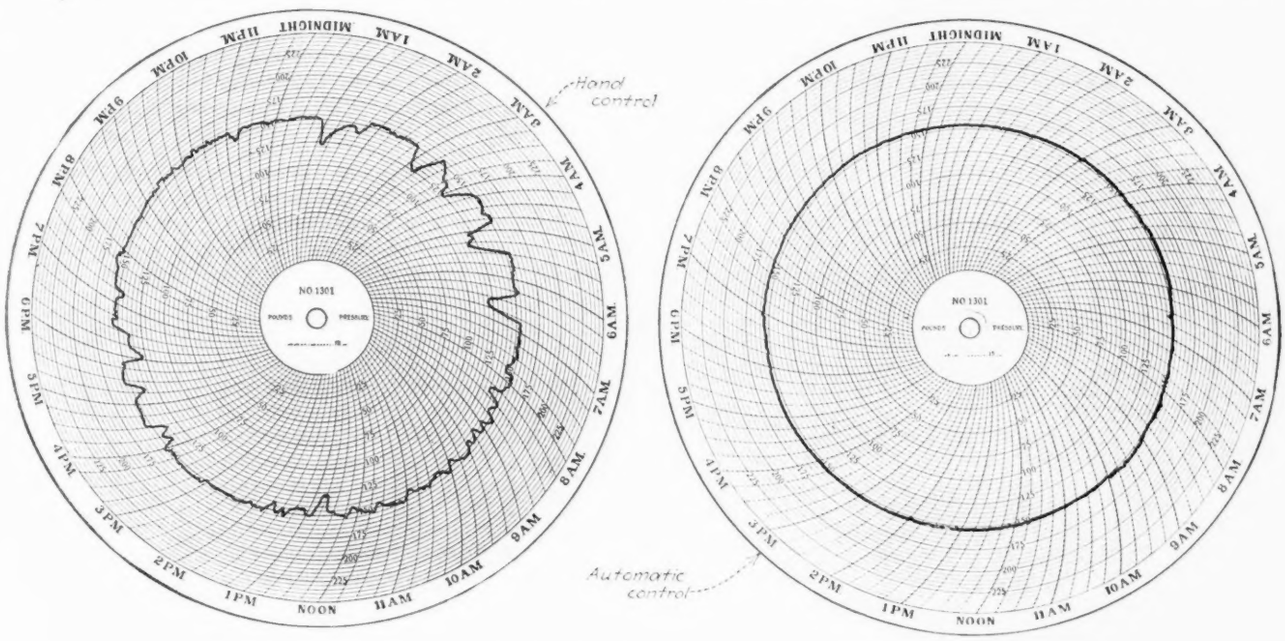


Fig. 2—Steam pressure charts showing improvement obtained with regulator. Left, hand regulation; right, automatic regulation

While the apparatus is extremely simple and cheap and perhaps not very scientific, its effectiveness has made a big saving. It was devised and installed by W. W. Mapes, chief engineer of the plant, about two years ago and has never given the slightest trouble. The installation was originally made as an experiment, but it has worked so well that it has never been replaced by specially designed apparatus.

Through co-operation of other organizations, the A.S.M.E. Boiler Code has been adopted in 19 states and 15 cities. In addition, the Code Committee has co-operated directly with various government departments having authority over steam-boiler construction. It has also co-operated and furnished information to boiler-inspection departments and authorities in many foreign countries.—*A.S.M.E. booklet on technical committees.*

High-Speed Alternating-Current Elevator Equipment

A Non-Sealing Type of Magnet, Built Like a Polyphase Induction Motor, is Applied to Operating the Controller Contactors and Brake—Multi-Speed Squirrel-Cage Motors Are Used Having Speed Ratios as High as Six to One

By ERNEST THURSTON
Chief Electrical Engineer, Haughton Elevator Co., Toledo, Ohio

SPEED, economy, safety and accuracy of handling are the attributes of modern alternating-current passenger and freight elevators. This combination of desirable features is credited to the design of the controller, motor and brake, three vital factors of every elevator equipment. As early as 1909 the trend of power for electric elevators was toward the use of alternating current. The alternating-current elevator had

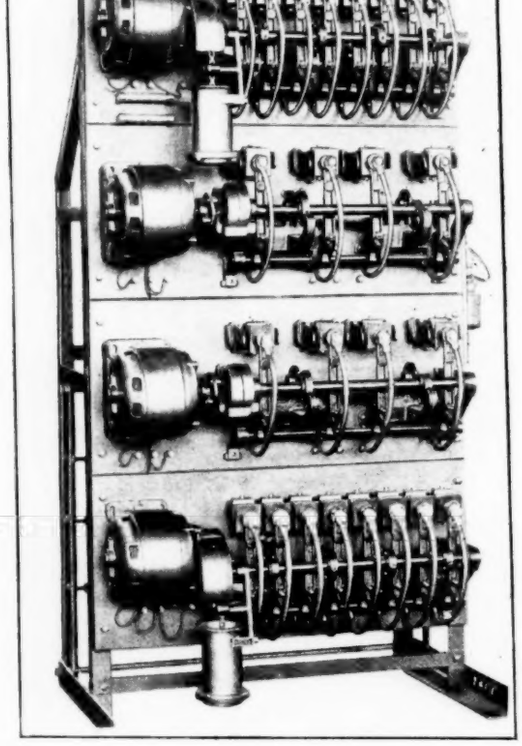


Fig. 1—Controller for two-speed squirrel-cage elevator motor

been considered unsatisfactory even for the slower speed cars, but the rapidly growing industrial centers were adopting alternating current for power applications.

As the demand for elevators operated from an alternating-current supply and for higher car speeds grew, the development of the multi-speed slip-ring type of motor materialized. Although this was a step forward and experience led to further development of this type, it was generally abandoned because of noise and difficulty in getting smooth control. After years of experimenting co-operatively by the Haughton Elevator Co.'s and the Lincoln Electric Co.'s research and electrical engineers, the squirrel-cage type motor has been adopted by these companies as the most serviceable, reliable and economical type elevator motor for alternating-current applications.

For the controller and brake, at the beginning, no satisfactory alternating-current magnets were available, so it was necessary to operate at the lower car speeds only. Many types and principles of alternating-current magnets were tried, and many were developed that were fairly reliable but that were still unsatisfactory for a large percentage of elevator requirements because of noise. Hence controllers for multi-speed motors were of many types, some requiring small motor-generator sets for direct-current magnets to avoid the use of alternating current for operating the control board.

The successful alternating-current elevators are the result of a decision to abandon the principles of control, brake and motor operation as used for direct current and study the problem on an entirely new and independent basis. The use of alternating current, without any transformation whatever, was the object; the motor had to be quiet and give smooth control of the car; a constant-pull magnet was desirable; the elevator brake should be quick, of short stroke and powerful, but quiet in operation. To accomplish this in the Haughton alternating-current elevators, non-sealing magnets are used on the controller and brake without oil immersion of any part; twenty-four contacts of one size are the greatest number used on any type of control, whereas forty was the former average. There is no transformation of current in any part and all current is interrupted when the elevator car stops; squirrel-cage motors up to 150 hp. are operating successfully and passenger installations at 550 ft. per minute have been serving busy buildings for several years.

Referring to Fig. 1, which shows the controller, the simple construction will be noted, and there are only four main magnets. These magnets are of the polyphase rotation-magnetic-field interchangeable type, and have a constant pull over the entire range of action which results in positive movement of all parts with the elimination of excessive strains and shocks on the parts and contacts. They also have the desirable feature of taking a constant current and do not require a large inrush current, common to other types of magnets.

Because the magnets do not seal, excessive strains do not occur, and the magnets' characteristics are such that they inherently protect against phase failure and

phase reversal, and do not allow the controller to be reversed in operation until the car has slowed down, even though the operator has moved the car-control switch to reverse position. On moving the car-control switch to reverse position it will cause the opening of the main line switch with power in addition to the gravity action. The control characteristics are such as to eliminate interlocks or auxiliary contacts and to lock mechanically the power switches open in the off position. The magnet construction is of the rotary type and is similar to a small squirrel-cage induction motor, and requires less current than the average sealing type of magnet.

The brake magnet, Fig. 2, has a constant pull, is non-sealing and is of the polyphase rotating-magnetic-field type, but reciprocating in operation instead of rotating. As seen in the figure, the stationary part is similar to a polyphase induction motor's stator with a laminated core and a distributed winding, where the rotor has a laminated core without a winding, but displaced partly out of line with the stator when the magnet is in the open position. There is no rotative effort but a tendency for the core to align itself with the stator. It will be seen that since the rotor core tends to align

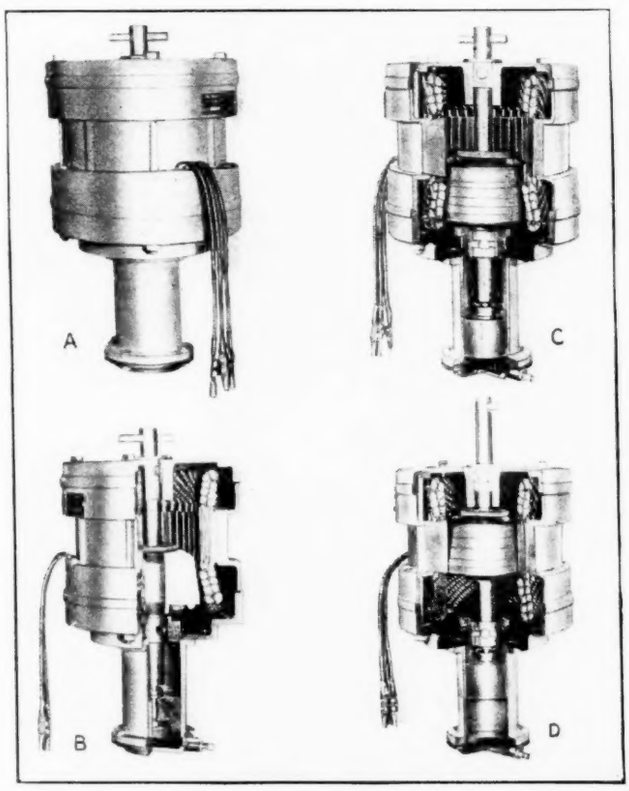


Fig. 2—Complete assembly and sections of non-sealing type brake magnet

A—Complete assembly of magnet. *B*—Section through stator and movable core. *C*—Section through stator, showing movable core in released position. *D*—Section through stator, showing the movable core in the full-stroke position.

itself with the stator core, it will not require a mechanical stop and therefore cannot cause a slapping noise. Because a polyphase distributed winding on a magnet produces a pull that is always considerably above zero, it will not cause a magnetic hum or vibration. By the shaping of the core face it is possible to produce practically any characteristic stroke-pull curve desired, and as the constant pull is most desirable for brake service, this is used so as inherently to eliminate any violent action of the magnet.

The elevator motor was of necessity very much a test tower development. The squirrel-cage type of motor was desirable, because practice has proved this to be the most reliable. It was next found that it was possible to build this type to be more quiet in operation than other types of alternating-current motors and it

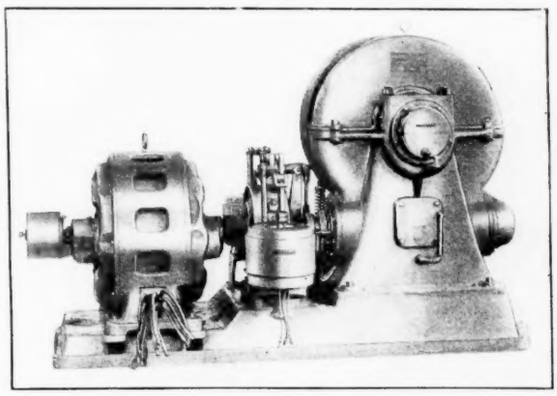


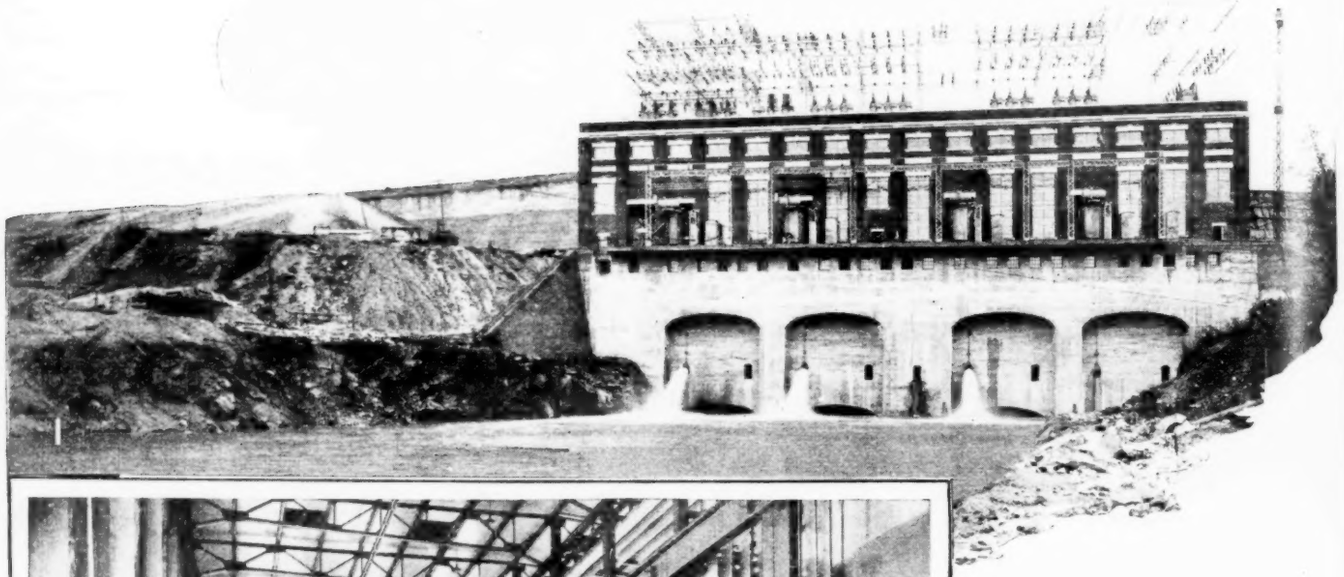
Fig. 3—Two-speed alternating-current geared traction-type elevator machine

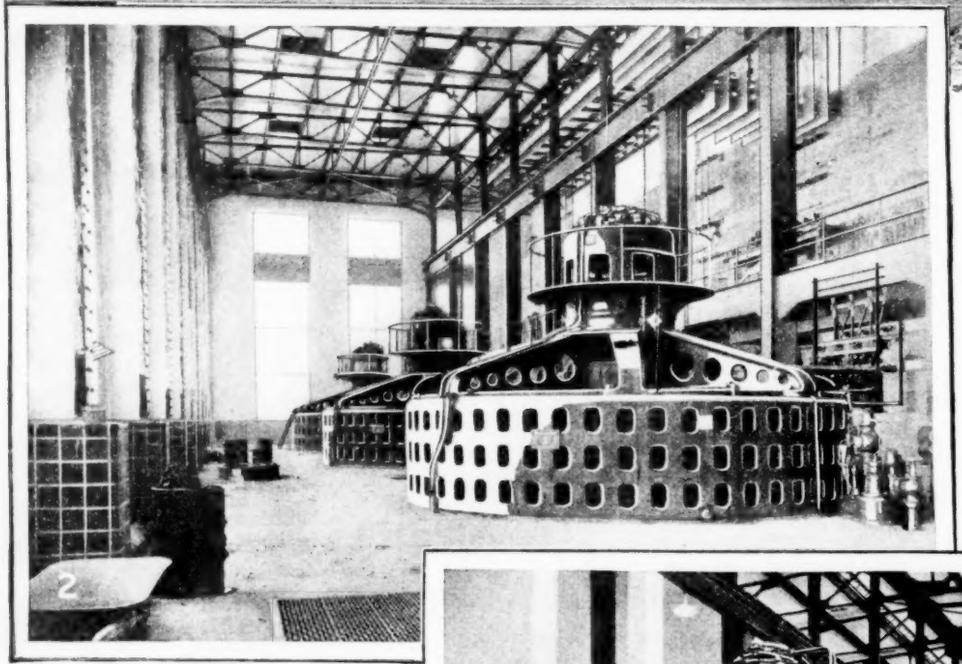
requires the simplest type of controller. To meet the requirements of elevator service, such a motor has to be one with a speed-torque curve that will give rapid acceleration and deceleration, a smooth control of speeds and positive response to the operator's control switch. It was necessary to develop a complete line of motors with these characteristics for all phases, voltages and cycles, as well as speed ratios of two to one, three to one, four to one and six to one, to cover the demand of elevator service. There are now many six-to-one motors in service having horsepower ratings ranging from 20 to 150.

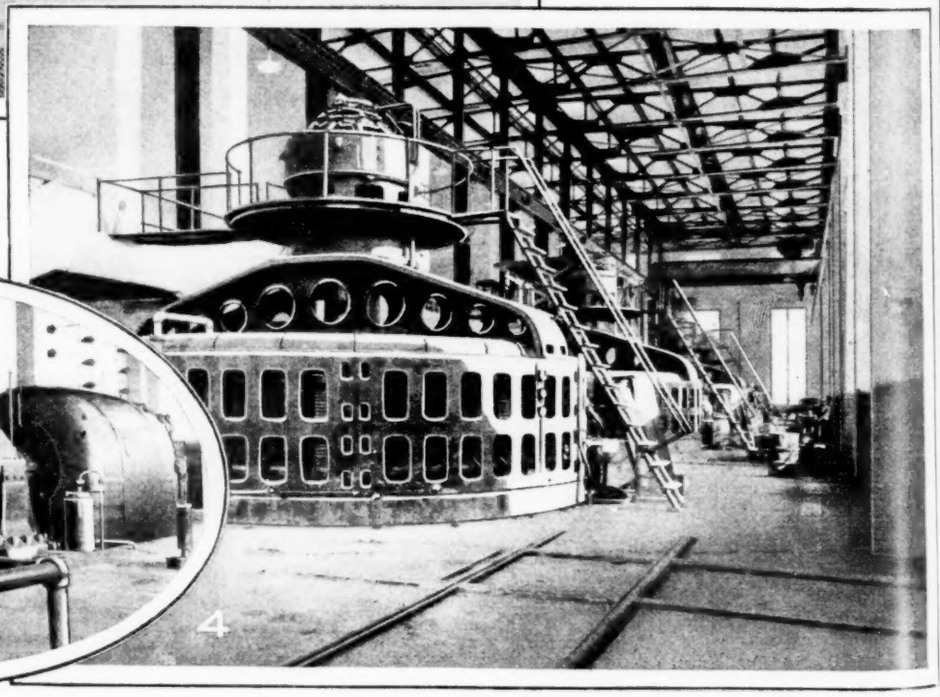
Factors in Smooth Operation

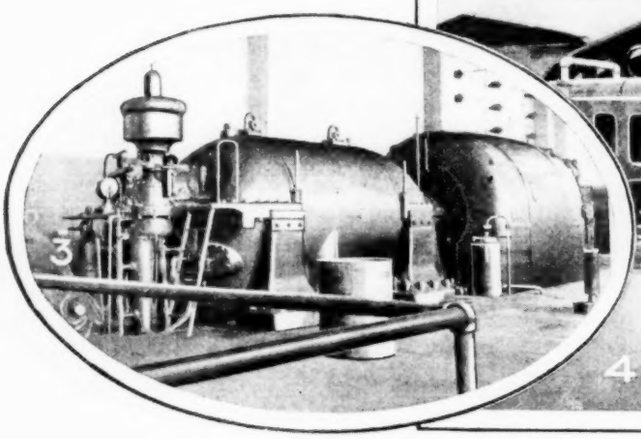
The degree of smooth operation is determined by the number of accelerating switches, combinations of motor characteristics with controller characteristics, a forced dynamic-braking action of the motor regardless of the operator, and a separate control of the brakes regardless of the forced dynamic action. The combination of these is essential for high car speeds with straight alternating-current service. After a number of years of service, this type of controller magnet and brake has proved so reliable that it has been adopted for the company's direct-current elevators for all capacities and speeds.

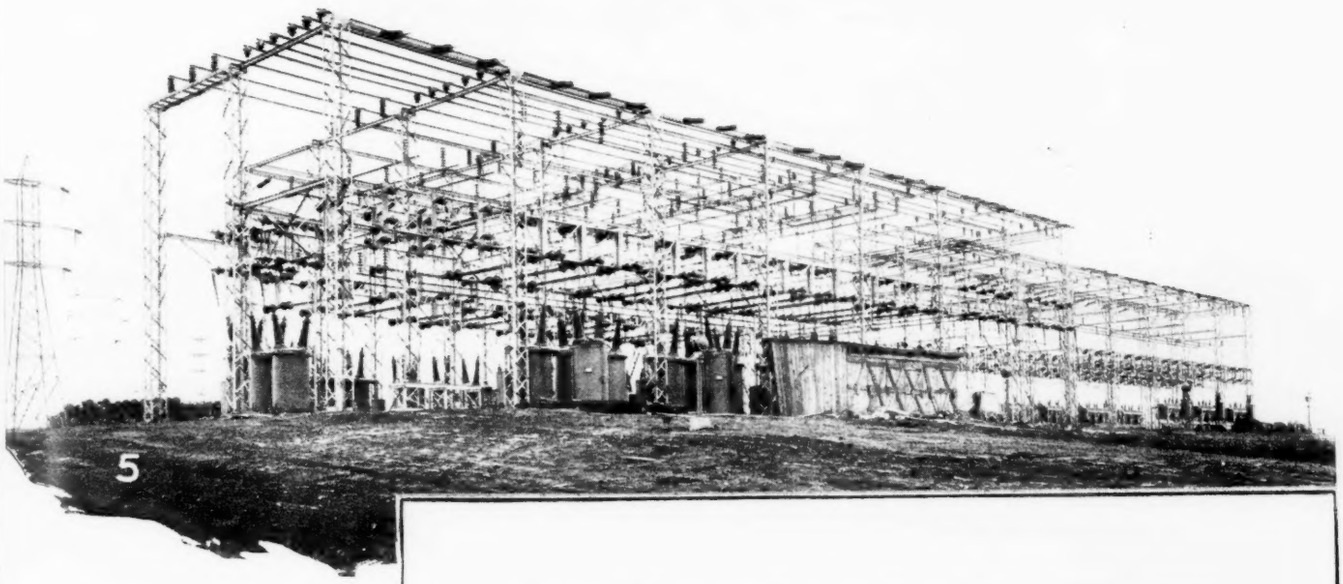
Tests made on a motor and controller by public-utility corporations showed a starting and accelerating power factor of 85 per cent on passenger elevators operating at 525 ft. per minute with average load and 75 per cent power factor when lifting full load. Elevators rated at 2,500 lb. lifted 3,500 lb. without any re-adjustments. Operating at full speed in one direction, the car control may be instantly thrown to full speed in the reverse direction without disturbing the power lines or causing passengers any objectionable sensations. Another test showed that a motor on a 425 ft. per minute elevator, when lowering rated load, returned to the power lines 24 per cent of rated horsepower of the motor. This same test showed a power factor of 77.2 per cent when lifting rated load.





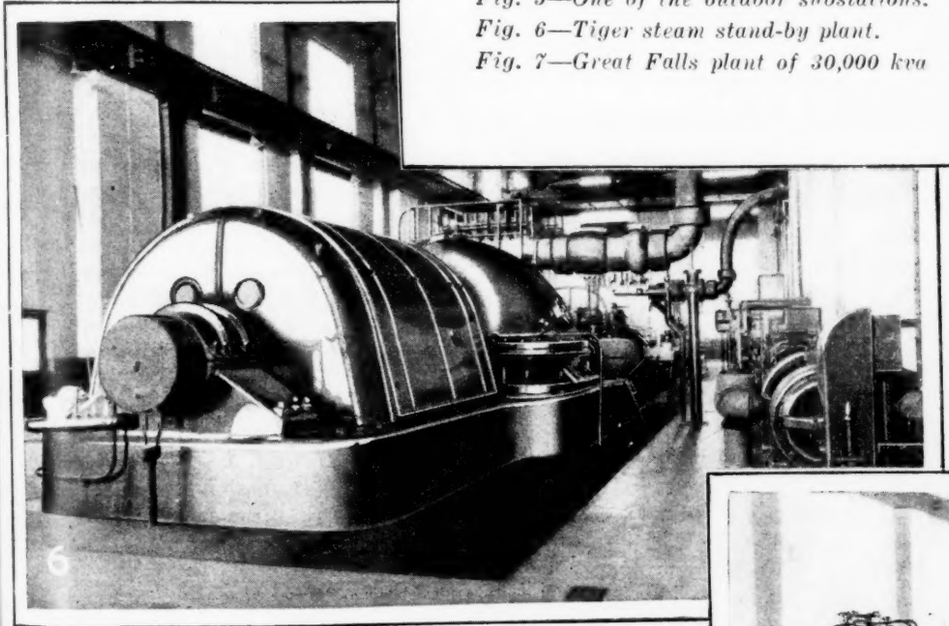


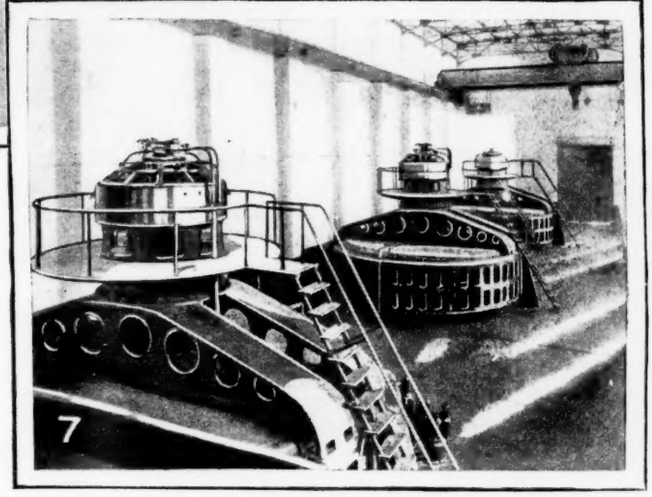




Some Plants of the Southern Power Company

Fig. 1—Downstream side of 99 Island plant.
Fig. 2—Rhodhiss contains 31,875 kva. of hydro-electric units.
Fig. 3—A turbine in Mt. Holly stand-by plant.
Fig. 4—Mountain Island plant contains four units totaling 75,000 kva.
Fig. 5—One of the outdoor substations.
Fig. 6—Tiger steam stand-by plant.
Fig. 7—Great Falls plant of 30,000 kva





Comparative Performance of Air Preheaters*

By NEVIN E. FUNK
Operating Engineer, Philadelphia Electric Company

THIS paper gives the results of tests on a number of boiler units equipped with air preheaters and one unit using unheated air. All the boilers are of approximately the same size, are of the same type, and have furnaces and stoker equipments which are similar. Some are equipped with economizers. Different types of air preheaters are used and the areas of the heaters are not the same. The curves which are presented show the comparative performance of the units. There is a distinct gain through the use of preheaters, both in the efficiency attained and in the flatness of the load-efficiency curve. The author states that the fires were easily maintained in better condition with preheated air.

THIS paper presents comparative data on different types of air preheaters used with boilers equipped with economizers and with boilers not equipped with economizers. The boilers in every case are of approximately the same design. It is hoped that the facts presented will be of value to engineers in the design of future stations. However, there is no intention of drawing any specific conclusions from the data presented in view of the danger arising from the general application of conclusions that apply only to a given set of conditions. The data will therefore be presented in comparative form, and the conclusions as to the application of the different equipment to designs varying from those herein described will be left to the judgment of each engineer in solving his own individual problem.

An extended description of the seven boiler settings covered by the tests is summarized in Table I, compiled to permit a ready comparison of the units. Table II gives the stoker characteristics. The differences in stokers and furnace volume will have some effect on the boiler efficiency, but the general designs (shown by cross-sectional drawings in the original paper) are so nearly the same that a comparison of air-preheater performance is but slightly affected.

Air Preheaters Compared

In Table III are given the physical characteristics of all the preheaters with the exception of the Ljungstrom, which cannot be compared with the others on the same basis. The tubular heaters are constructed of tubes of the same diameter and length. In event of damage to any of the tubes or to the plate headers in which they are inserted the faulty structure may readily be removed and renewed. Owing to their construction, welding of all parts of the plate heaters is necessary. It is difficult to locate leakage in such heaters and even more difficult to correct it.

In comparing the characteristics of these preheaters with each other and with a boiler without any preheater, the boiler numbers have been placed on all the curves to indicate to what units they particularly apply. To review the physical characteristics of the units compared, the following tabulation gives the economizer and the air-preheater equipment of each one of the boilers.

Boiler No.	Equipment
3	Economizer and small tubular air preheater
5	Economizer and small plate preheater, Connery type
6	Economizer and small plate preheater, B. & W. type
7	Ljungstrom air preheater only
8	Large tubular preheater only
23	Economizer only
59	Economizer, small tubular air preheater and water wall

The performance of boiler and economizer units equipped with air preheaters is compared on the basis of total heat injected into the furnace, including the heat in fuel and air above atmospheric temperature.

In Fig. 1 are two families of curves. Group A indicates the output of the boiler and superheater alone. Group B indicates the output of the entire unit including economizer and preheater. It is to be noted that the performance of the boiler alone without preheated air is poorer than that of any of the boilers using preheated air and that except at fairly high rating there is little difference in the performances of those using preheated air at low and those using preheated air at high temperatures. With the increase in rating, however, the boiler supplied with preheated air at low temperature maintains a much higher output ratio than do the two supplied with preheated air at higher temperature.

The author has no doubt of the accuracy of tests of units 7 and 8 so far as their relation to the test of unit 3 is concerned, but is inclined to believe that, although these were the actual performances obtained from the boilers, they are not indicative of what may be expected with highly preheated air. His belief is based on two outstanding conditions which prevent the attainment of high efficiency with these units. First, at high ratings the furnace refractories will not stand up under the higher preheated-air temperatures and it is necessary to reduce the percentage of CO_2 somewhat to preserve the furnace walls. Second, with the greater quantity of heat liberated in the furnace, the boiler alone apparently does not absorb as much and the temperature of the exit gases rises rapidly. This puts an extra burden on the air preheaters.

The first condition can be met by water-cooled furnace construction. The second condition can be corrected by the installation of increased boiler surface or a change in boiler baffling. These two points are emphasized because there might be a tendency, from an

*Abstract of paper presented at the Providence, R. I., meeting of the A. S. M. E., May 5, 1926.

analysis of these curves, to assume that the use of a preheater without an economizer is in general productive of lower efficiency. This is true for the particular design tested, but the author feels that there are errors in design and that the lower efficiency is not a fundamental characteristic of high preheated-air temperatures.

The B group of curves substantiate the conclusions drawn for the A group. It will be noted, however, that the curves for units 7 and 8 are much closer together than those of the A group, which indicates that the tubular preheater is performing somewhat better than the Ljungstrom preheater.

Attention is called to the fact that unit 3 shows a

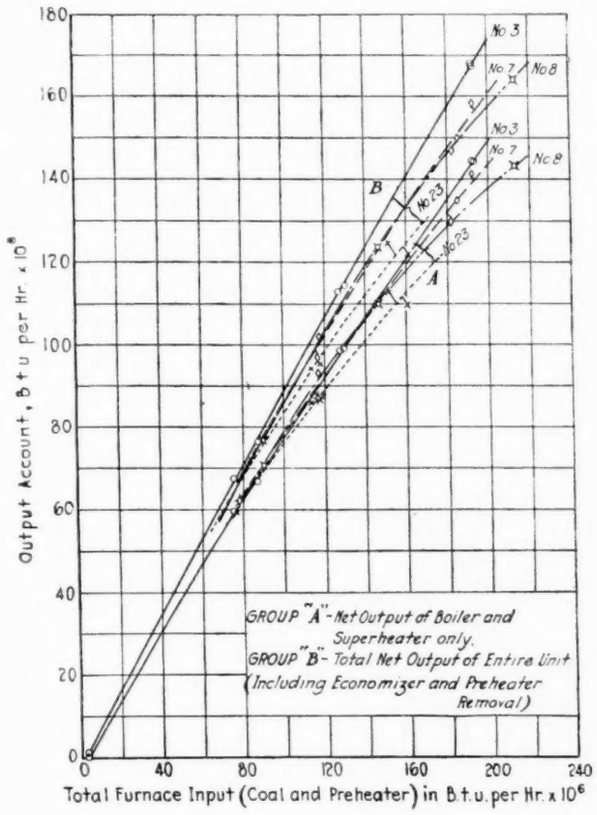

Output Account, B.t.u. per Hr. x 10⁶
Total Furnace Input (Coal and Preheater) in B.t.u. per Hr. x 10⁶
GROUP "A"-Net Output of Boiler and Superheater only.
GROUP "B"-Total Net Output of Entire Unit (Including Economizer and Preheater Removal)
No 3
No 7
No 8
No 23
A
B

Fig. 1—Relation of total heat output to total heat input

still better performance than either 7 or 8 since the deviation of the curves for these units and that for unit 3 is greater in the B group than in the A group. This, however, is due largely to the fact that the economizer reduces the flue-gas temperatures so that the air temperatures do not rise as rapidly as they do in 7 and 8.

Fig. 1 does not give a true comparison of the efficiencies of the boiler units for a given amount of fuel consumption, but does give the performance of the boiler surface. For this reason, curves have been plotted in Fig. 2 showing the efficiencies of these units at different rates of fuel consumption. These are over-

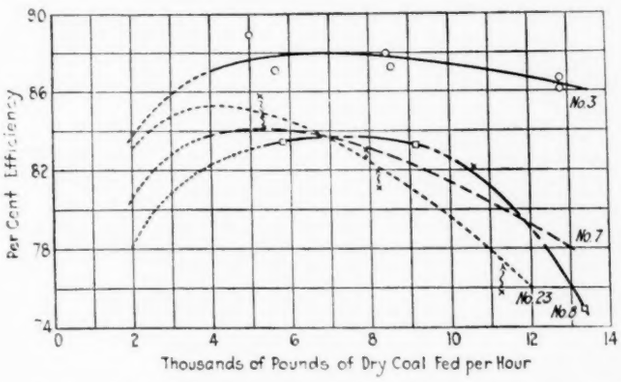


Fig. 2—Relation of boiler efficiency to rate of fuel feed

$$\text{Per Cent Efficiency} = \frac{\text{Net Heat to Steam}}{\text{Heat of Coal Fired}} \times 100$$

all efficiencies of boiler, superheater, economizer and air preheater. There are distinct differences in the shapes of these efficiency curves. Unit 23, which has no preheater, shows a rapid drop in efficiency with increase in rating. Unit 3, which is practically the same as 23, except that an air preheater has been supplied, shows an unusually flat efficiency curve.

The efficiencies of units 7 and 8 which have the large air preheaters are distinctly lower than the efficiency of 3, although they are somewhat flatter than and at heavy loads higher than 23. Unit 8 shows a rapid dropping off in efficiency, not due to the characteristics of highly preheated air, but to the fact that the boiler furnace is not properly designed to care for the high temperatures. The rapid downward bend in the efficiency curve of unit 8 is accompanied by severe burning of the extension grates of the stoker. This is apparently caused by the reflected heat from the bridge wall, and if the performance of a stoker with a similar ash discharge end can be used for comparison, the installation of a water-cooled wall at this point would raise by 3 or 4 per cent the lower end of the curve for unit 8.

In Fig. 3 comparative data are given on the boiler, economizer and preheater outlet-gas temperatures. At-

TABLE I—BOILER INSTALLATION CHARACTERISTICS
(B. & W. Stirling Boilers, 55 Tubes Wide)

Station	Boiler No.	Date Installed	Heating Surface: Boiler	Superheater	Economizer	Preheater	Water Wall	Economizer Feed Temp. Deg. Fahr.	Approximate Final Steam Condition: Lb. per Sq.In. Gage	Total Temp. Deg. Fahr.
Chester	3	10/31/24	14,217 sq.ft. 100%	2,582 sq.ft. 18.15%	5,250 sq.ft. 36.95%	22,072 sq.ft. T 154.8%	.....	172	257	652
	5	2/14/25	14,217 sq.ft. 100%	2,582 sq.ft. 18.15%	5,250 sq.ft. 36.95%	20,719 sq.ft. P 145.7%	.....	172	257	652
	6	12/6/24	14,217 sq.ft. 100%	2,582 sq.ft. 18.15%	5,250 sq.ft. 36.95%	22,500 sq.ft. P 158.2%	.....	172	257	652
	7	2/5/25	14,217 sq.ft. 100%	2,582 sq.ft. 18.15%	.....	64,960 sq.ft. L 457.0%	.....	172	257	652
	8	6/1/5	14,217 sq.ft. 100%	2,582 sq.ft. 18.15%	.....	50,276 sq.ft. T 353.5%	.....	172	257	652
Delaware	23	7/5/24	14,217 sq.ft. 100%	2,582 sq.ft. 18.15%	6,853 sq.ft. 48.2%	.....	.....	107	257	633
Richmond	59	10/8/25	15,692 sq.ft. 100%	2,822 sq.ft. 17.9%	7,515 sq.ft. 47.85%	22,072 sq.ft. T 140.7%	595 sq.ft. 3.79%	235	410	658

T—Tubular air heater. L—Ljungstrom heater. P—Plate type heater.

tention is called to the fact that both units 7 and 8 with the highly preheated air have higher outlet temperatures than unit 23 with cold air. Unit 3, however, with a preheated-air temperature of 300 deg. F., has

TABLE II—STOKER CHARACTERISTICS
(American Engineering Co., Taylor, Type H. C. 7)

Station	Unit No.	Grate Surface, Sq. Ft.	Number of Rams	Number of Tuyeres	Furnace — Volume Above Asphalt, Cu.Ft.	Furnace — Height of Mud Drum from Floor, Ft.	Ashpit at Heel of Fire — Width, Ft.	Ashpit at Heel of Fire — Depth Ft.,
Chester	3	310	15	21	6,650	11	3.8	5.3
	5	310	15	21	6,650	11	3.8	5.3
	6	310	15	21	6,650	11	3.8	5.3
	7	310	15	21	6,650	11	3.8	5.3
	8	310	15	21	6,650	11	3.8	5.3
Delaware	23	310	15	22	7,200	13	3.8	4.0
Richmond	59	337	15	25	7,780	13	3.8	5.3

an outlet-gas temperature considerably lower than that of unit 23, and unit 59 with the water-cooled walls has a lower temperature than any of the others. The economizer outlet temperatures are approximately the

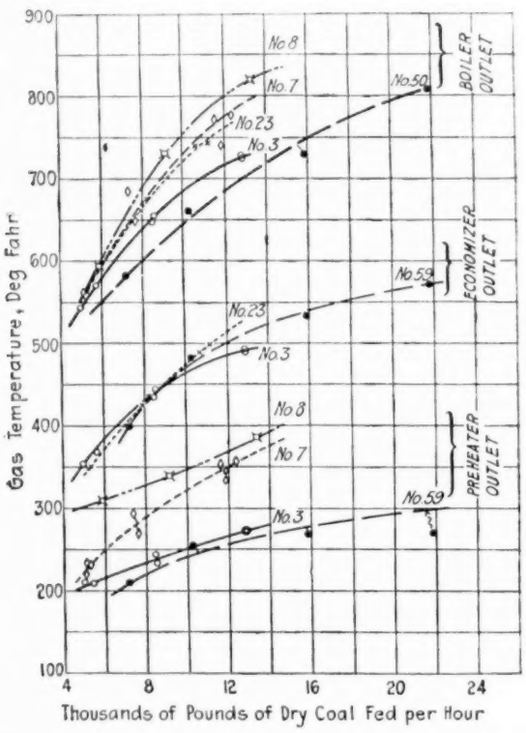


Fig. 3—Relation of gas temperatures to rate of fuel feed

same for all units having economizers, that of unit 3 being somewhat lower than that of 59. The increased temperature of economizer outlet gas in unit 59 is primarily due to the fact that the feed-water temperature is 63 deg. higher than that of unit 3.

The air preheaters on 3 and 59 are identical, and the exit gases from these two preheaters are at practically the same temperature. The air preheaters on 7 and 8, however, have considerably higher exit-gas temperatures, due apparently to the higher exit temperatures of gas from the boilers. This condition is more clearly shown in Fig. 4, in which the temperature drop in the flue gas and the temperature rise in the air supplied to the stoker have been plotted against percentage of boiler rating. In this figure, as in Fig. 3, it will be noted that the air preheaters of units 3 and 59 are almost parallel in performance, 59 showing a somewhat better heat transfer than 3. These preheaters were tested under practically the same condition of cleanli-

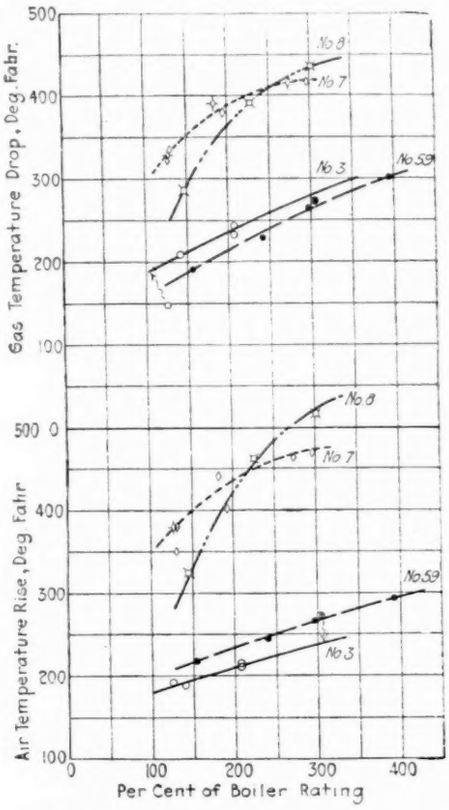


Fig. 4—Temperature changes through air preheater. Relation of gas temperature drop and air temperature rise to boiler rating

ness. Preheaters of units 7 and 8 reduce the gas temperature and increase the air temperature through a range from 50 to 80 per cent greater than the smaller air preheaters. This is to be expected on account of the larger area of heating surface.

Rate of Heat Transfer

It is interesting to note the rate of heat transfer through air preheaters of different types. The curves of Fig. 5 have been plotted to show the relation between the temperature drop of the gas and the temperature rise of the air. The temperature increment for the preheaters of units 7 and 8 is greater than that

TABLE III—PREHEATER CHARACTERISTICS

Boiler No.	3	5	6	7	8	59
Heating surface, sq.in.	22,072	20,719	22,500	64,960	50,276	22,072
Type	Tubular, B. & W.	Plate, Connery & Co.	Plate, B. & W.	Rotary, Ljungstrom	Tubular, B. & W.	Tubular B. & W
Rows of tubes	15	....	....	....	41	15
Tubes per row	90	....	....	....	75	90
Tube diameter—or thickness of gas passage, in.	2½	⅝ (gas)	1¼	....	2½	2½
Metal thickness	12 B.w.g.	1/16 in.	16 B.w.g.	....	12 B.w.g.	12 B.w.g
Length of tube, ft.	25	....	....	....	25	25
Overall duct height, ft.	....	15	24	....	....	....
Overall duct width	....	3 ft. 2 in.	4 ft.	....	....	....
Number of gas ducts	....	252	99	....	....	....

for units 3 and 59. Apparently, this is caused by the rapid increase of the temperature of the outlet gases in these two boilers. This throws more work on the air preheaters, increases the average temperature through the air preheater, and permits a high rate of heat transfer.

Two types of plate heaters were shown in Table III for units 5 and 6. In the figures shown so far, no information has been given relative to these two units, because no efficiency data have been obtained for the boiler units as a whole.

When new, the performances of the plate-type air preheaters are quite equal to the tubular air preheaters. It is, however, much more difficult to keep the plate-type air preheaters clean. For this reason comparisons of these different type air preheaters should be made after they have been in service for some time. With the desire to get accurate comparisons of the yearly performance that could be expected from the plate and the tubular preheaters, units 3, 5 and 6 were allowed to run under the same load conditions for about nine months before the data included in Fig. 6 were obtained. The air preheaters, boilers and economizers were all thoroughly cleaned so that there could be no question of discrimination in favor of one type of preheater. The boilers were then operated for approximately a month and then temperatures were taken at various ratings for a sufficient time to allow the temperature conditions to become settled. The resulting data are plotted in Fig. 6. It will be noted that there is a considerably less rise in the temperature of the

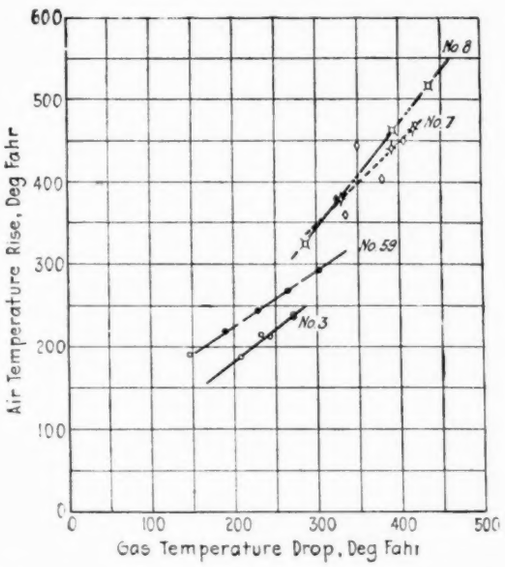


Fig. 5—Ratio of gas temperature rise to air temperature drop in air preheaters

preheated air in the two plate heaters than in the tubular heater. Likewise, the temperature drop in the gases is less in the plate heaters than in the tubular heaters.

The figures of relative temperatures for units 3, 5 and 6 are given with the understanding that they are not to be compared with data from 24-hour tests of clean boiler units, but are of relative value for boiler units under the usual operating conditions. They were taken from the charts of recording meters, and while an attempt was made to operate the boilers close to the average rating as plotted, there was some variation above and below this rating due to the fluctuations in station load and this, of course, has some effect on the performance of the thermometers. Figures substantiating the values given can be taken directly from the

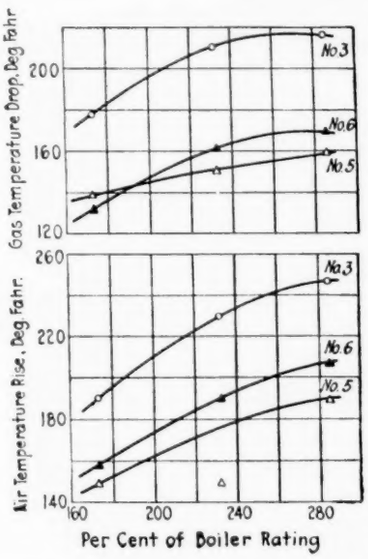


Fig. 6—Comparison of temperatures for plate and tubular heaters of equivalent heating surface

charts on these various boilers and always show a lower temperature of preheated air for the plate heaters than for the small tubular heaters.

The data given in Fig. 7 will be of considerable interest because they not only bear out data heretofore presented, but also show a definite change with the change in temperature of preheated air.

In Fig. 7, the air temperature for unit 23 is that of the boiler room, and the fact that it has decreased slightly with the increased rating merely shows that the room temperature has varied, since this air temperature has no relation to the boiler rating. It will be noted that the curve of combustible in the refuse for unit 23 is the highest of all. The temperature of preheated air of unit 3 varies from slightly below 300 deg. F. to about 350 deg., and the combustible in the refuse for varying ratings of this unit is less by about ½ per cent than the combustible in the refuse of unit 23. It must be noted, however, that the ashpit of unit 3 is somewhat deeper than that of 23, and this in itself may be responsible to some extent for the reduction in the refuse. The air temperature for unit 8 varies from 400 to 600 deg. F., and it is extremely interesting to note that the combustible in the refuse from unit 8 is the lowest of all. That is, the boiler with the highest preheated-air temperature has the lowest percentage of combustible in the refuse. The ashpits of units 8 and 3 are practically identical. The small diamond on Fig. 7 is a spot test for boiler 7, and it is worthy of note that its position between units 3 and 8 bears a close relation to its position between the temperatures of preheated air for units 3 and 8. This relation follows almost too closely to be a matter of chance, and there is apparently a definite relation between reduction of combustible in the refuse and increase in the temperature of preheated air.

The author appreciates the fact that an accurate determination of the combustible in the refuse is difficult and because of this fact he uses a small ash grinder. All the ash from a boiler test is run through this grinder and reduced to fine particles. The entire ash discharge from the test is then quartered to a laboratory sample by the method of the Bureau of

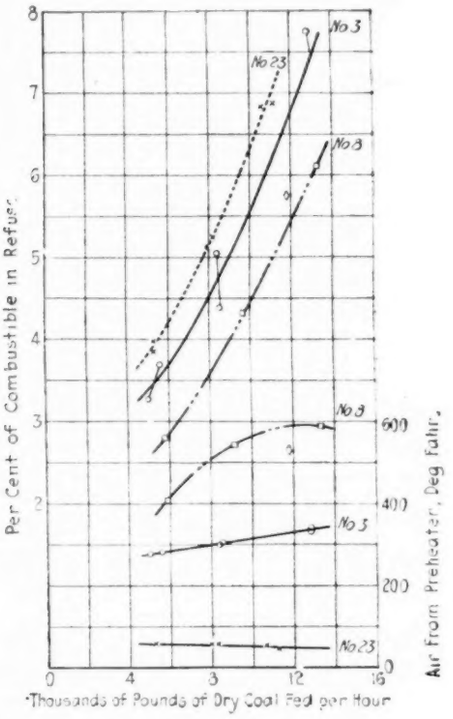


Fig. 7—A comparison of the reduction in the combustible in the refuse with increase in preheated-air temperature

Mines and is analyzed. In the test of unit 3 there are two values for approximately the same fuel rating. These are from two tests made while the boiler was operated first from a low to a continually higher rating and then back to a lower rating.

The data in this paper have been obtained from carefully made efficiency tests of all boilers for which efficiency curves have been given. Data for the boilers for which no efficiency tests have been plotted are not quite so accurate. An exception may be made of unit 59 for which the output and the temperatures have been quite accurately measured, but for which the fuel weight is not accurate and has not been given.

The performance of these preheaters must not be applied directly to different types of boiler installations without due allowance for changed conditions. A higher temperature of exit gas from the boiler or economizer with the same air-preheater surface area necessarily results in a higher stack-gas temperature, but it also results in a greater heat transfer through the air preheater.

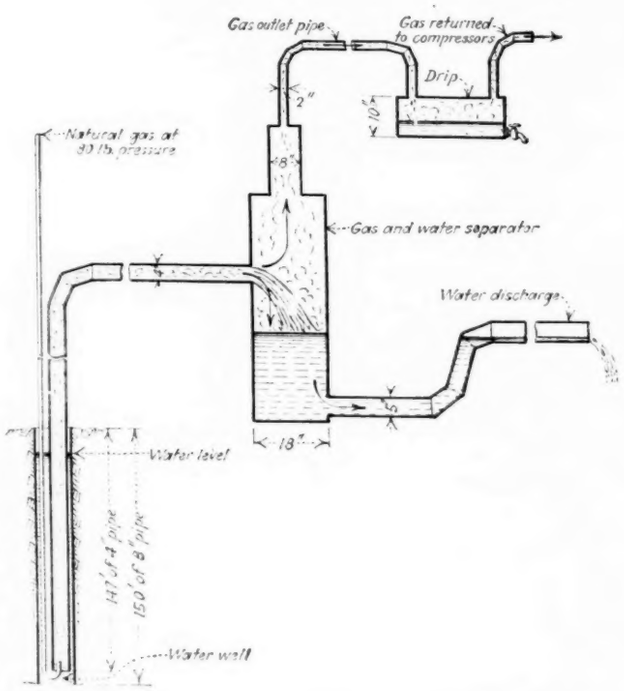
The data on performance seem to indicate that the plate heater is not continually so effective for a given surface area as the tubular heater. This, however, may be due to the particular design of the heaters and must not be taken as a condemnation of the plate heater or as an indication that the plate heater will always perform less satisfactorily.

Without stating any definite conclusion, the author feels that the plate heater will always be more difficult to keep clean and for this reason is likely to show a less satisfactory heat transfer than the tubular heater, which may be more easily cleaned. The Ljungstrom heater is even less difficult to keep clean than the tubular heater and for this reason will show a more uniform heat-transfer rate under continuous operation than either of the other types of heaters. The performance of the Ljungstrom heater in every-day operation, however, is likely to be misleading since the air leakage from the forced-draft fan into the flue gases through the rotor, due both to air entrainment and to pressure leakage, reduces the measured temperature of the flue gas below the actual temperature of exit gas from the rotor and leads an operator erroneously to feel tnat the flue-gas temperatures are low.

Natural Gas Pumps Cooling Water

The April issue of *Oxyacetylene Tips* describes an unusual layout ingeniously designed to use some of the gas discharged by a natural-gas compressor to pump water for cooling the compressor. The arrangement is shown in the accompanying figure.

This plan operates 24 hours a day, compressing natural gas for distribution to high-pressure mains. The use of an ordinary pump for supplying cooling water requires the services of an additional operator, so the apparatus shown was constructed with the aid of the



"Air" lift operated by natural gas, and constructed entirely by welding, pumps cooling water for the compressor

welding torch and operated by compressed gas from the delivery main. It is in effect an "air-lift" especially arranged to recover all the gas used. The principle of operation is obvious from a study of the figure. It is stated in *Oxyacetylene Tips* that no trouble whatever has been experienced with leaks.

Vital Heat Transfer Data for the Refrigerating Engineer

By H. J. Macintire
Professor of Refrigeration, University of Illinois

IN REFRIGERATION there is hardly any more important subject than that of heat transfer. The rate of heat transfer influences the design of the condenser, the brine cooler, direct expansion piping and every special use that is made of brine and ammonia piping for the production of cold temperatures. Yet, in spite of the importance of information on this subject, there is the greatest difficulty in securing reliable information. Apparently, there is no agreement as to the coefficients of heat transfer, and considerable confusion exists on that account. In consequence the whole subject of heat transfer can be understood better if some of the reasons of this lack of agreement or knowledge can be discussed, and therefore this will be done briefly before the consideration of the special coefficients which are most usually accepted by refrigerating engineers.

Heat Transfer Action

If a copper plate one foot square and of No. 16 gage be tested for conduction only, the value of k (the number of B.t.u. per square foot per one degree F. difference of temperature per hour) would be about 26,000. If the plate was of iron, this value would become about 6,500 B.t.u. In practice the unit rate of heat transfer from a surface is only from 200 to 300, although in very special cases, as in Orrak's tests on steam condensers, with practically no air present, the value may go up to 1,000. This remarkable drop in heat transmission is occasioned by the presence of a layer of stagnant water of, say, 0.01-in. thickness, on the sides of the plate being tested, so that it would appear that the problem is not so much a matter of passing heat through the metal of the walls as it is one of passing it through the surface films.

A fluid, like water or brine, passing through a pipe or tube does not have a uniform velocity throughout its cross-section. As a matter of fact the velocity is zero at the pipe surface, and a maximum at the center of the water column, but as the average velocity for the cross-section of the pipe is increased, the surface film is partly washed or rubbed away, to be replaced immediately by other fluid, so that the film is always present. However, the action of rubbing away the film does permit a greater heat transfer, and so the average velocity of the fluid in contact with each of the surfaces is an important factor.

The presence of air in the heat-transfer apparatus is a serious factor at times, especially in condensers. The velocity of the ammonia or other refrigerant in the usual condenser is low, and the air, being non-condensable, will form a film adjacent to the surface and will decrease the heat transfer accordingly.

Besides the action of the surface film, there are factors tending to make more or less of the surface non-effective. It has been mentioned what the effect of a film of water on the surface will do. This harmful effect is caused by the fact that the film has no appreciable velocity. However, if the pipe or tube is filled or partly filled with the condensate in the condenser, or with the gas in the evaporator, the *effective* area is reduced. The function of a condenser is to condense vapor by the absorption of the latent heat of liquefaction by the condensing water. Having liquefied the refrigerant, the condensate should be removed immediately. The presence of a liquid does no good. Globules of liquid are forming on the surface, during each unit of time, which means that the surface is wet, and this is conducive to maximum heat transfer, but the liquid globules which continue to adhere to the surface act as insulators to oppose continued heat transfer. It was because of these facts that the so-called flooded condenser failed both in theory and in practice, although high values of heat transfer were obtained in individual condensers under certain circumstances.

On the other hand, the evaporator, as for example, the shell-and-tube brine cooler, should operate flooded. The greatest heat transfer is when the liquid refrigerant is adjacent to each and every square foot of the evaporator surface. The gas occasioned by the boiling action has no appreciable heat capacity. Its presence cannot do any good and it actually does great harm. The shell-and-tube brine cooler lends itself to a quick freeing of the gas, whereas the submerged piping of an ice-making brine tank may require the gas formed to pass through 500 to 1,000 ft. of 1¼-in. piping before it can escape into the suction line to the compressor.

Transfer in Counter-Current Condensers

The advantages of the use of the counter-current water and gas flow in condensers have been given considerable discussion in the literature. The only real advantage is in the subcooling of the liquid condensate by having the latter come into metal contact with the coldest water available at the plant. However, in the large refrigerating plants a special cooler is used for this particular purpose. The superheat in the ammonia is removed in about 40 linear feet of 2-in. pipe of the atmospheric or the double-pipe condenser, and during the remainder of the liquefaction period the temperature of the ammonia remains constant. It is a mistake to believe that all the surface is performing at the same rate, even though the heat transfer is dependent on the value of the mean temperature difference (t_m) and the total heat transfer is given by the equation $Q = A\ k\ t_m$, where A is the heat-transfer surface in square feet and k is the coefficient of heat transfer. As a matter of fact very careful tests, during which the condensate from different parts of the bleeder atmospheric condenser were measured, indicated that from 40 to 70 per cent of the total condensate takes place in the upper pair of pipes, the larger percentage occurring with the use of the coldest cooling water on these pipes.

One other factor affecting heat transfer which needs

to be given careful consideration, is the condition of the heat-transfer surfaces. The inside surface may become gummy with a mixture of oxide of iron, or mill scale, and lubricating oil from the compressor. On the water side of the condenser there may be either a soft sediment or a hard scale, depending on the kind of condensing water used. It is needless to say that heat-transfer surfaces must be kept in a clean condition if satisfactory operation of the plant is to be expected.

To recapitulate, refrigeration brings factors into play in heat transfer which appear to be more severe than in the design of steam and hot-water problems. Some of the surface may be non-effective, sometimes dormant and at other times taking such a small amount of the load as to lower decidedly the average value of the coefficient of heat transfer. The velocity of the gas in the pipe, and of the water or the brine, as the case may be, is an extremely important factor in the scouring of the surface and the partial removal of the surface film of liquid or gas. In this connection the first principle in heat-transfer design should be considered; condensers should have the liquid removed as quickly as is practical and evaporators should have the surface flooded with the liquid as much as possible.

Using the foregoing analysis, bleeding of a condenser, if arranged so as to permit free draining of the condensate from every pair of pipes, is to be preferred. The value of k varies from 200 to 300 B.t.u. per square foot per degree F. difference of temperature per hour when tested under good conditions with no air present. The common type of atmospheric condenser with the gas entering at the top and the condensate traveling through the entire length of the condenser is less efficient than the double-pipe condenser where most of the liquefaction occurs at the bottom of the condenser incidental with the oldest condensing water. The value of k for the double-pipe condenser is taken as from 125 to 200 B.t.u. and the common-type atmospheric condenser from 60 to 125 B.t.u.

Advantage of the Shell-and-Tube Type

The very best design from the viewpoint of compactness of surface and good heat transfer is the vertical type of shell-and-tube condenser. This is a more recent design, and the value of k is stated to vary from 150 to 300 B.t.u. In this case the condensate flows by gravity promptly from the tube surface, and the water in the tubes has a velocity limited by the friction of the tube surface on the water flowing down through the action of gravity. The submerged condenser is never used in stationary plants for ammonia, although it is still a good type for carbonic installations because of its relative simplicity and the ease with which leaks of the gas can be made a minimum. The low velocity of the water passing the condenser surfaces and the flooded condition of the coils keep the value of k low, from 30 to 40 B.t.u.

Brine, water and milk coolers are designed individually. The problem here is somewhat different from that in the case of condensers because of the consideration of the safety of the compressor. In order to keep away from the danger of bringing back liquid ammonia to the compressor, it is usual to operate so that the upper part of the heat-transfer surface will be exposed to superheated gas only. The method of operation, however, is not conducive to the best efficiency of the cooling surfaces, as one-third or more is in contact with superheated gas, which inherently does not permit a high value of k. The best example of progress along this line is to be seen in the design of brine tanks for ice manufacture.

The old value for ice-tank coil design was from 12 to 15 for the value of k. More efficient agitation of the brine in the tank was developed in process of time and the value of k increased to about 17½. Finally, the flooded coil was made possible by interposing a liquid separator, the accumulator, in the gas return line to the compressor combined with a device for precooling the liquid feed to the expansion valve so as to overcome the necessity of permitting the 10 to 15 per cent of the weight of the refrigerant passing through the expansion valve into the evaporator coils in the form of a vapor. In this manner the value of k has been increased from 20 to 25 and 30 with good agitation of the brine, and even higher values have been reported with excessive brine agitation. In addition, the accumulator permits the ready removal of oil and other impurities.

The only form of brine cooler now used to any extent is the shell-and-tube design. Usual values for shell-and-tube brine coolers have been low, from 90 to 100 B.t.u., but no doubt greater values can be obtained if care in operation is taken and the amount of liquid fed into the cooler great enough so that, with the use of some trap or separator, the evaporator surfaces may be kept flooded without continuous danger to the compressor.

In this connection comes also a consideration of the temperature of evaporation in the cooler. The suction pressure maintained must be such that the temperature difference between the brine and the ammonia will not be too great, otherwise the cooler cannot be operated flooded, nor will the operating conditions be uniform, consequently, the difference in the temperatures should be from 5 to 10 deg. F.

Coefficients in Other Apparatus

The double-pipe brine cooler is considered to have a larger value of k, of from 100 to 150 B.t.u., but these values are dependent on the velocity of the brine and all the formulas advanced to show heat transfer for double-pipe coolers are expressed as a constant times the square root of the brine velocity. In the case of water coolers, the Baudalot type has a value of from 90 to 100, whereas in the shell-and-coil, with the ammonia in the coil for safety, the value is much lower on account of the low velocity of the water and is taken as from 25 to 50 B.t.u., although values considerably higher have been obtained with special designs.

Finally, there is the consideration of the cooling of air. Here the velocity of the air is very low, being a natural circulation as a rule and the frostation becomes a decided factor. If the cooling coils are brine, the value of k varies from 2 to 2½ and in the case of direct expansion, since the gas renders some of the surface non-effective, this value becomes 1½ to 2. Keeping the surfaces wet will raise the values of k to from 5 to 8, provided a forced system of circulation is used. However, bunker coils are seldom used at present, and when air is to be cooled it has been found more desirable to make use of water or water and brine sprays. In all the cases mentioned it is customary to take the outside area of the pipe, although there is a recent tendency to take the area *exposed to the refrigerant* in calculating the total heat transfer.

Preheated Air Experience

PREHEATED air, used for years at sea, has apparently justified itself on land. Mr. Funk's paper, abstracted on another page of this issue, is one of the first reports of systematic study of this departure.

Investigations of this nature are fraught with unusual difficulty, due to the fact that they must be made on full-sized equipment in regular operation. As boilers are installed from time to time and as repairs are made, many changes are introduced, so that hardly any two boiler settings are identical. This complicates the comparison of separate parts of the equipment, but is an unavoidable consequence of the ever-present engineering necessity of carrying the load. Those who are inclined to pick flaws and split hairs should bear in mind these limitations when studying Mr. Funk's report.

The report calls attention to the fact that in studying the heat-absorbing characteristics of the boiler surface by itself, it is not sufficient to charge the heat supplied in fuel alone. That in the air must be included. If the losses are to be figured above room temperature, so also must the heat supply. Of course when the unit is considered as a whole, the preheat cancels out, since it is in a sense a recirculating stream. As in the case of the extraction turbine, the basis of comparison must be modified to fit new conditions.

Better combustion and reduced flue-gas temperature are the benefits of preheat. The offsetting features are the space required by the preheater and the cost for installation, operation and maintenance. These are evidently not prohibitive.

The air preheater is strictly analogous to the feedwater heater. There is a place for it in every plant—even in a boiler plant without engines. Every fire must have air and does better with hot air than with cold. Every boiler discharges flue gas at high temperature and can gain by reducing that temperature. As experience develops, the air preheater should find a large place in the power-plant field.

Powdered Coal for Small Boiler Plants

A LARGE factor in the first cost of a pulverized coal plant is the pulverizing equipment. The operation and maintenance of this machinery usually requires a somewhat higher type of boiler-house operator than is frequently found in the small plant. These two considerations have tended to retard the application of powdered coal in furnaces under such small boilers as are found in schools, small office buildings and smaller industrial plants—those plants which are now unquestionably in the hand-fired class.

The machinery for feeding and burning the powdered coal may be made simple and may be adapted to control quite as easily as fuel-oil equipment. Furthermore, its cost should be moderate. Such equipment should require little care and maintenance and could be easily handled by the average boiler-room attendant. It therefore appears that if coal could be supplied in pulverized form to the small plant, there would be no difficulty in burning it. This situation suggests the questions: "Why cannot the coal be prepared by dealers in a central pulverizing plant and be delivered to customers in tank wagons just as fuel oil is delivered? What are the possibilities of such a scheme?" In the first place the dealer could operate and maintain his pulverizing plant relatively cheaply. It would pay him to employ competent repair men and operators. He could use tank wagons such as are proposed in Germany for delivering this powdered coal. He could also secure a higher price for his powdered coal on account of the fact that it is dry and that it is pulverized. Further, he could convert cheap dust and slack coal into high-value fuel.

The purchaser would get a high-grade processed fuel which he could burn with high efficiency. He would have little ash to remove and could burn lower-grade and hence lower-priced fuel than he now uses on hand-fired grates. He could also practically eliminate the smoke nuisance from his chimney, and except for some dust discharged from the chimney, he could approach anthracite in cleanliness.

This plan is not entirely visionary. It has been tried in Seattle and is said to have proved satisfactory. Some wide-awake coal dealer will be trying the plan in the East, and the probabilities are that it will prove a real success.

The Question of Overhead Charges

A PROFESSOR of mechanical engineering once characterized the factor of safety used in boiler design as the factor of ignorance. In examining many engineers' estimates and reports, one is forced to believe that a similar factor of ignorance is being used in the calculation of overhead charges.

In any discussion on the cost of power the item of overhead charges usually proves a stumbling block to any agreement as to what the costs really are. From outward appearances there is little understanding as to what the overhead item should include and how much in percentage of the capital investment it should be. On the one hand are found various companies making use of an overhead that includes interest, depreciation, obsolescence, amortization, taxes and insurance, while others go no farther than to charge interest, taxes and insurance, forgetting the wear and tear on the equipment. While for the purposes of establishing a basis for existing or increased rates, a public utility may be justified in including all the items listed, for the industrial plant the middle course of including interest, depreciation, taxes and insurance is the more logical and permits one to find more accurately the real cost of the power generated.

The interest rate is beyond discussion inasmuch as

the cost of borrowed money is at once ascertainable. Taxes may be obtained from paid tax bills and usually will be found to be far below the three per cent engineers have become habituated in using, for machinery bears a lower rate than buildings and real estate, and if depreciation actually takes place, the taxes logically shrink from year to year, making the average rate approximately one-half that of the first year. In fact in some states machinery is not taxed save indirectly. Likewise, the cost of insurance seldom needs to be a matter of doubt, and as in the case of taxes, the face of the policy and the premium should have yearly reductions.

Only depreciation need ever be a dubious item. Concededly, machinery does wear out and this wear should be offset by a suitable charge. How long a machine will continue in working condition should not be a matter of doubt to an experienced engineer. Knowing the history of similar units, the probable age of an engine or boiler can be predicted with fair accuracy. It is folly to assume a life of five years when similar units are lasting twenty. It is only through the employment of experience and intelligence that depreciation can be ascertained with any degree of accuracy. By doing this, one will not meet so frequently with the paradox of a depreciation charge so high that the plant capital has been recovered twenty years before the machinery is actually replaced.

Electrically Driven Auxiliaries In Industrial Power Plants

IT REQUIRED a long time for engineers to comprehend the economic value of electrically driven auxiliaries in power plants. The opinion held in general, used to be that it did not make any difference how much steam was used for the auxiliary drives as long as their exhaust could be absorbed in heating the feed water. The fact that the greatest loss of heat is in the circulating water from the condensers or in the exhaust to atmosphere, if the main units operate non-condensing, was generally accepted as something according to the laws of nature and there was not much that could be done to change these conditions.

Gradually the idea got over that the smaller the amount of exhaust steam from machines producing the auxiliary power, the more of the exhaust from the units generating the main power load could be absorbed in the feed water and returned to the boiler, the heat being made available for generating power on the upper end of the thermal cycle. As the main units are the most efficient, they will produce the auxiliary power with a minimum steam consumption, and will make possible the returning to the boilers the exhaust steam from the generation of a maximum increment of the station load, with a resultant increase in the efficiency of the main units.

What is true with respect to electrically driven auxiliaries for a condensing plant is of equal importance to the isolated plant that is operating non-condensing and has only a heating load to absorb the exhaust steam for part of the time. During the heating season when all the exhaust can be utilized, power is generated at the highest economy, but in the summer months most of the exhaust goes to the atmosphere and the cost of generating power is greatly increased. Anything that can be done to keep down the amount of exhaust during the period when it cannot be absorbed in the heating system, will improve the thermal efficiency of the plant. If the load on steam-driven pumps requiring from four to five times as much steam to develop the same power as the main units, is transferred to the main units, the amount of exhaust steam from producing this power will be reduced in almost direct proportion to the efficiency of the two classes of units.

Experience has shown that in a large office-building power plant, changing from steam driven to electrically driven auxiliaries, including the refrigerating machines and other equipment, resulted in over fifty per cent reduction in the yearly steam consumption for power generation and heating. The saving made in this case was sufficient to pay for the entire change in less than two years. Changes that will result in the possibility of cutting the steam consumption in half are certainly worthy of careful consideration.

Steam-Turbine Fallacies

ANYONE who has carefully studied the theory of steam turbines must be amazed at the splendid appreciation of underlying principles that the early inventors, such as DeLaval, Parsons, Rateau and Curtis, embodied in their first machines. This fact is more amazing when one recalls that steam-turbine theory as we know it today was practically unknown at that time.

Numerous excellent textbooks are available on the underlying principles and theory of steam-turbine design. No inventor at the present time need attack the subject without a careful study of this theory. Yet there are many men who believe that they have new ideas on steam turbines and who devote much time and money to the development of these ideas without making such careful studies. In many cases this effort and expense is wasted owing to a failure to understand clearly some simple theories of the action of steam in a turbine.

For example, the energy entering a simple turbine is proportional to the square of the steam velocity leaving the nozzles. The energy leaving the turbine is proportional to the square of the steam velocity leaving the blades on its way to the exhaust. An inventor assuming that the difference between these two quantities could be turned into work, recently provided devices on the wheel to destroy the velocity of the flowing steam so that the velocity leaving the blades would be small. He believed that all this velocity head would be thereby converted into work. A more careful study of the subject would have indicated to him that friction losses and eddies set up in his design convert much of the velocity energy into heat rather than into work and produce the well-known phenomena of "reheat." Naturally, his turbine was not a success.

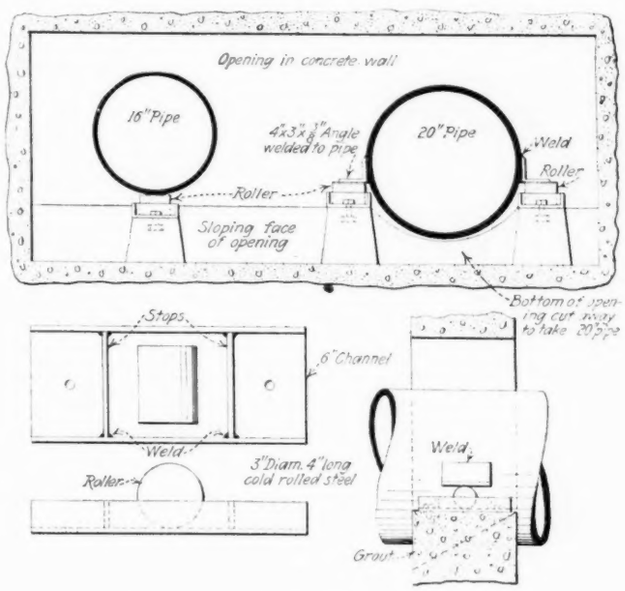
Some inventors fail to realize the great losses involved in eddies and whirls. Others seem to favor complex designs and do not appreciate the fact that simplicity of design generally leads toward efficiency as well as to low cost of manufacture.

These paragraphs may come to the attention of some who are considering the invention of a new form of steam turbine. Our message to such men is to get a thorough grasp of steam-turbine principles before undertaking to develop these ideas. Steam turbines lend themselves more readily to theoretical treatment than was the case with reciprocating engines.

Practical Ideas From Practical Men

Pipe Expansion Rolls and Supports

Recently, I had occasion to alter the run of a 16- and a 20-in. pipe line so that they had to pass through a concrete wall. As there was an opening already in the wall, it was decided to use the bottom of the opening to carry the weight of the mains and arrange the support at this point to take care of the expansion, which was estimated to be about 2 in. As we could not use any of the standard types of roller supports, we decided to use one of our own design, which was made up as follows:



Arrangement of roller pipe supports

A combined roll and carrier were made from a piece of 6-in. channel with two pieces of plate 1 in. high, welded into the bosom, about 6 in. apart, to serve as a stop for the roller, and also a retainer for lubricating grease. The roller was cut from a bar of 3 in. diameter cold-rolled steel and made long enough to roll clear inside the channel. Outside of these stops holes were punched in the channel for ¾-in. anchor bolts. As will be seen from the sketch, the bottom of the opening through the wall sloped about six inches, which necessitated cutting away the concrete at the back and building up in front.

Taking the case of the 16-in. pipe, it was jacked up so that it was possible to insert the channel and the roller. When the support was properly located, a form was built around it, the anchor bolts put in and a rich grout poured in and well tamped down. When the concrete had set, the pipe was lowered on the roller.

With the 20-in. pipe it was necessary to cut away the concrete in the bottom of the opening to clear the pipe, and also at the sides to take care of the supports. As there was no room under the pipe for the support, without a lot of cutting, a piece of heavy angle was welded to each side of the pipe to make a bearing, and the same type of roller and support as used for the 16-in. pipe was placed, one on each side, and anchored and grouted in place in a similar manner. The pipe was then let down on to its rollers, and the job was complete. This somewhat crude method of taking care of the pipe expansion proved satisfactory.

Hollywood, Calif. MAURICE C. COCKSHOTT.

Switch for Changing Transformer Bank From Delta to Star

It was recently found desirable to make some changes in the switching equipment on the high-tension side of a bank of transformers connected to a 40,000-kva. generator. This generator is normally feeding through a star-connected transformer bank to a 104,000-volt bus. The load on this bus falls off considerably at night,

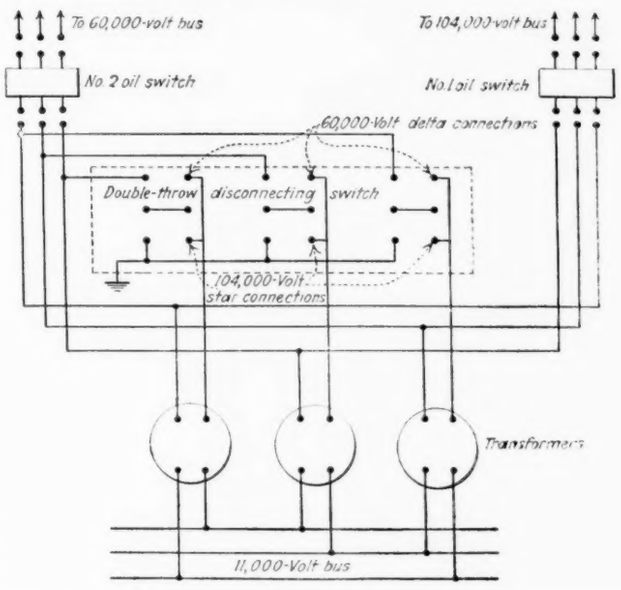


Fig. 1—Diagram of switch and transformer connections

and it was desired to transfer this unit to the 60,000-volt bus in order to increase the station output and by relieving the load on other plants to make best use of the river flow.

The transformer bank had been originally connected to two 104,000-volt buses through the oil switches Nos. 1 and 2 shown in Fig. 1. No. 2 oil switch was disconnected from its 104,000-volt bus and connected to the 60,000-volt bus. Also, the double-throw switch shown in the diagram and in Fig. 2 was installed in a convenient location. The down position of the switch

connects the transformer bank in star and grounds the neutral, where the up position connects the bank in delta.

Blocking switches are mounted on the switch frame, which are mechanically operated by the double-throw switch. These blocking switches are in series with the closing coils of the oil switches and are so arranged that the 104,000-volt oil switch cannot be closed when the transformer bank is delta connected and, in like manner, the 60,000-volt oil switch cannot be closed when the transformer bank is star connected.

These transformers have a balanced relay protection taking current on the high-tension side from bushing-type series transformers in the oil switches. The series transformer connections from the two oil switches are arranged so that the protection is operative without change when the unit is connected to either bus.

The double-throw switch used was made up from the standard three-phase 104,000-volt disconnecting switch used in the power house. The alterations consisted of the addition of lower contacts, the blocking switches and the steel structure for supporting the

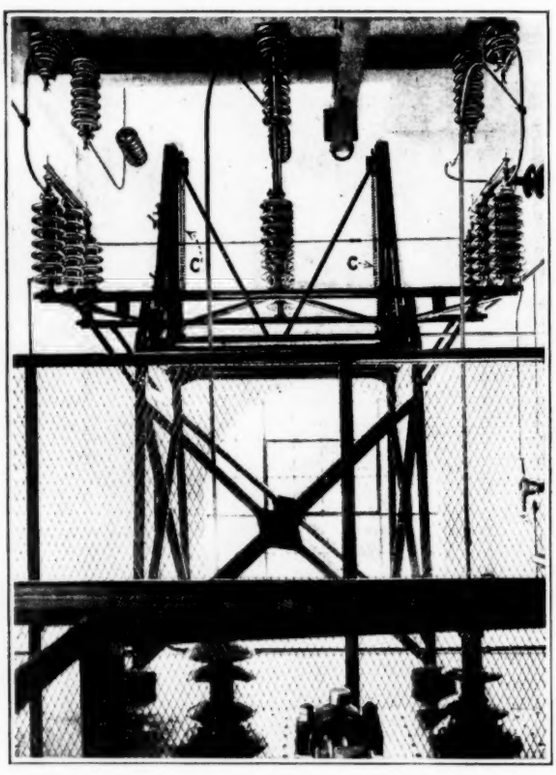


Fig. 2—Assembly of transformer change-over switch

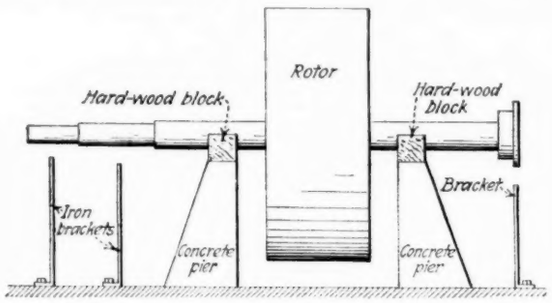
switch frame and lower contacts. The switch is hand operated by means of a crank connected by shafting and gears to the driving shaft of the switch. On this driving shaft are two sprockets which engage the chains shown at *C* in Fig. 2. On these chains is suspended the steel truss which carries in turn the insulators on which are mounted the switch blades. This truss is held steady by two vertical guide rods upon which it slides up and down. In the figure the switch is shown closed for the star connection. On the ceiling can be seen the switch clips for the delta connection, mounted on the lower ends of the insulators.

This installation has proved entirely satisfactory in service. The unit can be taken off one bus and transferred to the other in approximately 20 minutes.

C. R. REID,
Power House Superintendent,
Shawinigan Water & Power Co.
Shawinigan Falls, Que., Canada.

Checking a Large Rotor's Shaft Under Difficulties

One time, the company with which the writer is connected, received a cablegram from half across the world to ship immediately a new rotor complete for a large vertical-shaft generator. It was naturally asked why this was necessary, and we were told that the shaft



Arrangement used for checking rotor shaft

was crooked and it was known to be crooked because the purchaser's erector said so and the machine vibrated badly, proving the shaft was crooked.

Fortunately, we had a first-class erecting engineer a comparatively short distance away and cabled him to investigate. The customer was somewhat peeved when our man reported, for he considered sending him was questioning his ability and veracity. He at first refused to let the erector work on the machine as he was going to have a new rotor. However, after some diplomatic argument, the erector was permitted to check the rotor.

There was not anything in the way of a lathe that would swing the complete rotor, so the erector worked out the scheme shown in the figure. Two concrete piers were built and capped with hardwood blocks. These blocks were notched to make 90-deg. Vs and lined with sheet copper. They were greased liberally and the rotor placed in them. Several brackets were forged and bolted to the floor. These brackets were made of various heights so that an inside micrometer could be used between shallow cups made in the bracket ends and the bottom of the shaft. The shaft was checked at the coupling and several points above and below the rotor. Readings were taken 90 deg. apart, the rotor being turned with a rope wrapped around it over the polepieces and led to the crane through a snatch block.

A number of checks were made to prove that the readings were consistent, and these showed that the shaft was well within the allowances, both as to being straight and round. The customer's erector grudgingly admitted these facts and consented to allow our man to look for the real trouble. The waterwheel was found to be a little out of level and the wheel and generator were not lined up properly. Correcting these errors gave a fine running outfit.

N. L. REA,
Construction Engineer,
General Electric Company.
Schenectady, N. Y.

Comments from Readers

Why a Vacuum Could Not Be Obtained with the Air Ejectors

While reading the article on air ejectors by Charles E. Colburn in the March 16 issue, an incident came to my mind, which happened while I was assistant engineer on one of the Shipping Board vessels in 1920, and which I thought might interest other engineers.

The equipment consisted of a multi-stage marine turbine for going ahead and a single-impulse stage for going astern, with surface condenser and rotary condensate pumps and two air ejectors. The trouble started when the turbines were being warmed up, the vacuum gradually dropping to 10 in.; even with both ejectors 15 in. of vacuum could not be obtained. The steam strainers were removed from the ejectors and found perfectly clean; being of a fine mesh, it was not thought anything could have passed that would not pass the nozzles. Air leaks were looked for, but none were found even after flushing the surface condenser and partly filling the turbine with water.

I then suggested to the chief that we examine the nozzles, and upon removing them we found a piece of scale in each, hardly larger than a pinhead. The ejectors were reassembled and 28.5 in. vacuum was easily obtained with one ejector.

After this experience I always made a practice when overhauling the ejectors to clean the nozzles thoroughly, as well as the strainers. This, by the way, was my first experience with air ejectors, but through reading an article in a current engineering magazine I was well posted beforehand.

Eagleville, Pa. E. J. MEYER.

Exhaust Versus Live Steam for Heating

Having been a reader of *Power* for a number of years, the writer is naturally interested in articles that have appeared from time to time on the subject of exhaust steam versus live steam for heating.

In the issue of April 20, 1926, a letter from L. H. Stark at Milwaukee, Wisconsin, aroused my interest—particularly the paragraph which points out the effect on the steam flow, due to the engine pulsations. This calls to mind a theory advanced by one of our local engineers in regard to this same thing. In most discussions of this subject the technically trained engineer makes much of the fact that a certain B.t.u. content of the live steam has been extracted in its passage through the prime mover, but the practical man insists that in spite of this fact better results from the viewpoint of actual fuel economy will be obtained with exhaust steam for heating.

The engineer referred to advances the idea that the improved results observed where exhaust steam is used are partly attributable to improved efficiency of the boiler. This is explained on the theory that the intermittent pressure, due to the engine's valve action, acts as repeated hammer blows which jar steam bubbles loose from the boiler-tube surface as rapidly as they are formed; whereas without this pulsating effect, there is a tendency for these steam bubbles to enlarge on the tube surface until the surface tension is such that they break away.

Under these last conditions there would always be a certain area of the tube surface covered with steam bubbles, which would act as an insulating layer, thereby lessening the rate of heat transfer. We have not seen this theory advanced elsewhere, and are offering it here for the purpose of further discussion.

Minneapolis, Minn. BERRY ERVIN.

Effect of the College on Engineering

What is termed the overproduction of engineers from our colleges, and the effect on the salary level, is really an increase in the quality of the product. The standards are being raised as the college man's value is appreciated. The recent graduate is crowding us old timers for our jobs, and we shall have to meet this competition by keeping up to date in our profession instead of complaining about our troubles.

As the appreciation of the value of college training increases, the so-called "practical engineer" is going to be reduced in the power-plant field, and this man eventually will be forced out of the executive positions. Why? Because engineering is an exact science and the college man is replacing the guess-again artist. We cannot sit back and expect our years of practical experience to keep us ahead of the game.

I know what the practical engineer thinks of the college man and he is underestimating him. His four years in college have given him an advantage that the practical man is overlooking. The college man has had four years of the concentrated extract of experience built into him. Certainly, he got it out of books; that is the quickest way to get it, and the practical man is going to lose out unless he starts to get the same thing, the fundamentals and the world's offering of experience. The college man will reduce the time spent in securing the necessary experience and pass the practical man in a comparatively short time, because experience teaches the trained man more and in much less time, and he will not make nearly so many mistakes.

It is clearly evident that the companies using engineering talent are giving the college man preference over men who have had years of experience, for no other reason than his greater efficiency. This should not discourage the home-grown engineer. He has every advantage if he will get that which he lacks. Book learning and practice should go hand in hand. It costs practically nothing but effort, and he can double his value.

We are paid just about what we can sell our time for. If we cannot prove this value by results, then someone else will.

So often the engineer says the management will not back him up; that is, buy the equipment necessary to reduce the cost of power. This is because the engineer

is not salesman enough to get his ideas accepted. He has not established the confidence necessary or considered the problem from the management's viewpoint. There is no organization that will not spend money to make money if the manager has confidence and is sold on the man doing the work and his idea, and he will pay well for it too.

No doubt there is an overproduction of engineers. When there is an overproduction of apples, the culls are thrown out and the good ones still sell for a good price. This law is holding good with us. There is a better product coming into the field, and we must either get out or improve ourselves to meet this competition. Instead of complaining, I think I would go the other fellow one better or get into work more to my liking. L. A. COWLES.

Vermillion, S. D.

Needed—A Standard for Comparison of Operating Costs

Mr. Diman's communication relative to comparison of costs of purchased and manufactured power, published in the April 13 issue of *Power*, is timely and worthy of a great deal of consideration.

Before deciding whether to purchase or manufacture industrial power, an engineer must know not only at what cost the present plant makes power, but also at what cost a well-designed and properly managed plant could produce power. It is in the latter question that a knowledge of detailed costs of other isolated plants is essential. The only criterion for this purpose are the actual records of continuous performance of the most economical plants, and a knowledge of the details of cost are necessary in order that a proper value can be placed upon the conditions that are not identical in the plants that are being considered. Greater publicity of detailed records of efficiencies and costs would be of great value if they could be recorded by a standard code for calculation and tabulation. At the present time without such a code, the publication of this information is only of general interest as the length of time to make these records comparable with the records of a particular plant is prohibitive. The lack of a code of this type is the greatest obstacle to the intelligent comparison of isolated power plants, and the increasing interest in this type of plant is so great that it is reasonable to predict that the adoption of such a code will occur in the near future.

A knowledge of the detailed costs of power is of value only in the efforts to secure lower costs in the isolated power plants. They are not comparable and therefore are of no value in comparison with detailed costs of central-station power. The only things comparable between purchased and manufactured power are the ultimate costs of each. A knowledge of the detailed costs of purchased power will not help the engineer in securing cheaper power and is of no more interest to him than the knowledge of detailed costs of fuel, oil, water or any other commodity.

The industrial power engineer has two effective means of reducing the cost of purchased power. One of them is competition; reduce the cost of isolated plant power and the selling price of central station power will have to come down in order to compete. The other means is by increasing the volume of purchased power. This can be accomplished by demonstrating to certain types of industrial plants that they can purchase power cheaper than they can make it. The most valuable agency in either of these methods is greater publicity of detailed costs of isolated power plants, but even that is only of limited value until there is a standard code for comparison.

The industrial power engineer can do greater service in reducing the cost of industrial power by spending all his energy in the study of isolated plant costs than he can by delving into the detailed costs of central station power. F. M. GIBSON.

Newton Center, Mass.

Why Not a True Comparison of Public Utility and Industrial Power Costs?

The letter entitled "Why Not a True Comparison of Public Utility and Industrial Power Costs?" by Walter G. Diman, in the April 13 issue, brings out some interesting points, and there is no doubt that we are greatly in need of more reliable data on the operating costs of both public utility and private power plants.

As suggested by Mr. Diman, the methods of prorating the average generating and distribution costs between the large and small consumer should be thoroughly investigated. The subject is involved, and it is comparatively easy to make out a fairly good case for any system of rate distribution which may be satisfactory to a public supply company, but to prove that it is not fair to the consumer is a more difficult matter. This problem should receive the fullest consideration from those whose duty it is to protect the public's interests. With this end in view it is advisable that as much information as possible should be collected and presented in an unbiased form.

If the conditions are such that the small consumer carries too large a share of the burden and the large consumer too small a share, they should be corrected, and this would of course have an important bearing upon the installation of private generating plants.

The writer has no personal interest in public utilities, and is in fact more interested in the design and installation of private plants. At the same time he is free to admit that the case for the private plant is often not as clear as many engineers would make it out to be.

We are too prone to assume that if it can be shown that in any particular case, a factory can generate power more cheaply than it can be bought, a private plant should be installed, and we often criticize the management if this is not done, but in many cases, looking at it from the viewpoint of profit and loss, the management is right.

Let us look at the matter from the manufacturer's point of view. If we assume that a power plant would cost $75,000 and that the manufacturer is able to raise that amount of money, the question then is: Do the anticipated profits from a power plant offer not merely an adequate return, but the best possible return that might be obtained from the investment of this amount.

If, for instance, he should conclude that he could make a more satisfactory profit by purchasing improved machinery or by extending his business, why should he invest in a power plant. Moreover, even if on paper it looks like a fifty-fifty proposition or perhaps a little better in favor of the power plant, would it not be wise to invest the money in a business that he does understand, rather than in one that he does not?

There is a great deal of temptation for those who

are interested in the installation of power plants, to ignore the foregoing considerations; at the same time nothing is to be gained in the long run by refusing to face the facts, and undoubtedly in many cases the decision to purchase power is quite justified even when it can be shown that it might be generated at a lower cost.

J. O. G. GIBBONS.

Newark, N. J.

Lack of Standardization Causes High Power Cost

One of the factors that is responsible for high power costs in industrial plants is lack of standardization in both power equipment and operating methods. Choosing one particular industry, such as textile mills, one can find nearly every type of power plant from the most obsolete to the most modern by visiting only a dozen plants. Right in this locality are several textile plants and two of them manufacturing the same line of goods are as unlike as could be imagined. One has hand-fired boilers operating at 100 lb. pressure, the other stoker-fired boilers operating at 200 lb. pressure, the power requirements and process steam demand being nearly identical. Obviously, the two boiler plants cannot both be the proper thing for the conditions, being so widely different in design and operating practice.

Now any engineer, either industrial or a central-station representative, will admit that the prime-movers committee of the N.E.L.A. has done much to improve the design and operating methods in central stations in the last ten years, so why could not a similar committee be organized by textile manufacturers' associations, to report on suitable standard equipment and operating practice in textile plants? A few mills have correctly designed power plants, but these are exceptional rather than typical in this industry. For instance, one textile plant in this locality installed the following equipment about two years ago: Water-tube boilers for 250 lb. pressure fired by powdered coal, and bleeder turbines. With a steam flow at the turbine throttle of 30,000 lb. per hour, 27,000 lb. is extracted at 15 lb. pressure, only 3,000 going to the condenser. Now this plant is ideal for that class of work, but why do we not see more plants of this type, especially those installed within the last three or four years?

A near-by plant operates boilers to supply process steam only and purchases all its power, and still another plant of the same company generates as much power as possible on the process steam demand and purchases the balance. A fourth plant operates its engines condensing, generating all power that way, and runs a separate battery of low-pressure boilers for process steam.

If these plant owners had an advisory committee backed by funds jointly contributed by many manufacturers, there would be more plants like the first one, using high-pressure equipment and extracting 90 per cent of the total steam flow from the second stage of the turbines, instead of using the haphazard methods of the other three plants.

In 75 per cent of all textile plants it is impossible to generate all the power from the process steam at initial pressures below 200 lb. The correct initial pressure will lie between 200 and 300 lb. with a back pressure of 15 lb., higher initial pressure being required if much processing has to be done at higher back pressures.

It is not to be expected that a power committee would recommend the immediate changing over of all inefficient plants at once, even though money would be saved by doing so. But many of these plants already have changes under way or they are contemplating an extension, and unless they are wisely guided they often spend more money for inefficient equipment than the proper equipment would cost. For instance, one plant has started to renew its boilers at the rate of one each year. These are of the five-tube type 150 hp. each and hand-fired, operating at 130 lb. pressure. One old boiler is taken out and a new one put in each year with no change in the setting, not even adding one cubic foot to the furnace volume which is too small.

Another plant has two water-tube boilers good for 200 lb. pressure, operating in a battery at 110 lb. with several old fire-tube boilers. The process steam is expanded from 110 lb. to 20 lb. in single-cylinder engines developing about 200 hp. and a 500-hp. condensing engine carries the rest of the load. If the 200-lb. boilers were cut off from the old battery and supplied steam to a properly designed back-pressure engine 150 deg. of superheat being used, the power available from the process steam would be practically double that which is developed at present. By their method of operating these high-pressure boilers they have merely secured additional capacity, completely overlooking a chance to reduce their annual power cost several thousand dollars.

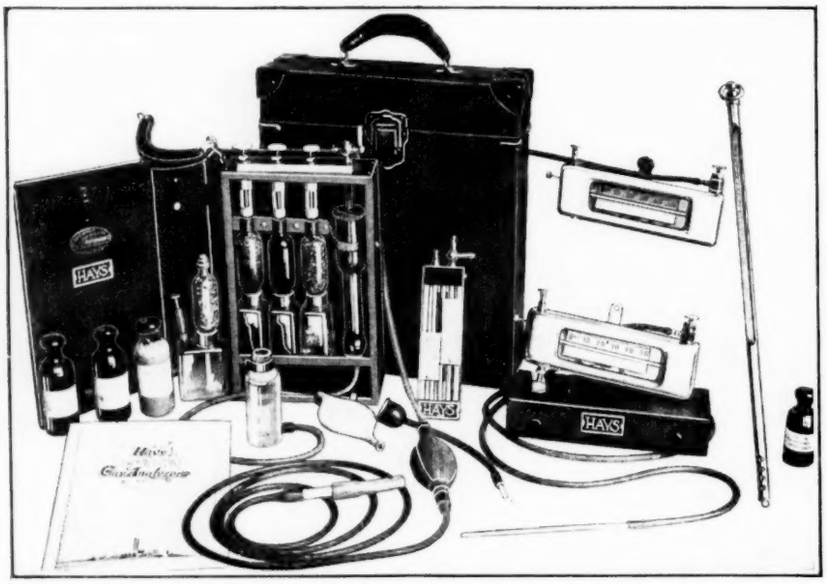
Too much equipment is purchased by managers who have no engineering training and who are too busy with other problems to take sufficient time to analyze the power problem. Frequently, the man in direct charge of the power plant is incapable of deciding such things as additions to the plant or the proper type of prime mover to select. It often is impossible for the engineer to see how a back-pressure unit using 35 lb. of steam per kilowatt-hour can be more economical than a condensing unit at 17.5 lb. per kilowatt-hour. In proof of this last statement, I will cite an experience of mine.

Several years ago I put a problem up to a meeting of practical operating engineers. My plant had a 250-hp. engine run condensing using about 5,000 lb. of steam per hour and the dyehouse used 5,000 lb. of live steam per hour at 40 lb. pressure. When I asked them if I would save coal by installing a back-pressure engine to exhaust at 40 lb., thus reducing the load on the main engine, I was unanimously advised that such high back-pressure would increase the coal bill and that 15 lb. was the limit on using exhaust steam. But directly against this advice we installed a vertical high-speed engine belted to the same lineshaft as the large engine. It developed about 100 hp. and no live steam was used afterward in process work, which reduced our coal consumption by about one ton per shift. A close analysis of these problems will reveal possible savings even though none are apparent at first glance. The ratio of power to process steam will, of course, vary in each plant and different plants have different load factors, but considerable standardization can be adopted with results favorable to the balance sheet.

But suppose industrial plants had preceded central stations in this matter of high-pressure and bleeder turbines instead of following them and had adopted it ten years ago, which they could have done if they had at their command an organized committee to dig up the necessary facts, the money spent on investigation would have been returned a hundredfold.

Brightwood, Mass. A. F. SHEEHAN.

New and Improved Equipment



Test set includes flue-gas analyzer, thermometer and draft gage

Convenient Test Set for Combustion Engineers

In the accompanying illustration are shown the various accessories included in a convenient test set, specially designed for service men, combustion engineers and others interested in the quick determination of combustion efficiency and the cause and location of troubles in combustion work. This set, which is being featured by the Hays Corporation, of Michigan City, Ind., consists of a portable flue-gas analyzer with the necessary chemicals, a steel-armored flue-gas thermometer and a draft gage, all compactly arranged in a light leather case, measuring 4x14x18 in., and weighing, with the equipment included, less than 20 lb. With all this equipment in the case there is still room to carry the few tools that may be needed.

The gas analyzer shown is a standard Hays machine of the three-chamber type for determining CO_2 and also, if desired, the oxygen and carbon monoxide. If only CO_2 readings are to be taken, a single-chamber analyzer may be substituted, giving additional room in the case. At the right of the illustration is shown the draft gage, which is of the adjustable inclined-tube type 9 in. long and 4 in. high. The range is ½ in. of water, either draft or pressure, with graduations in hundredths. For higher ranges the Hays vernier-type draft gage may be substituted. The gage is self-contained in a leather case, as is also the analyzer. Either one can be carried or used independently of the other, and of course both may be placed in the carrying case for immediate transport from one location to another.

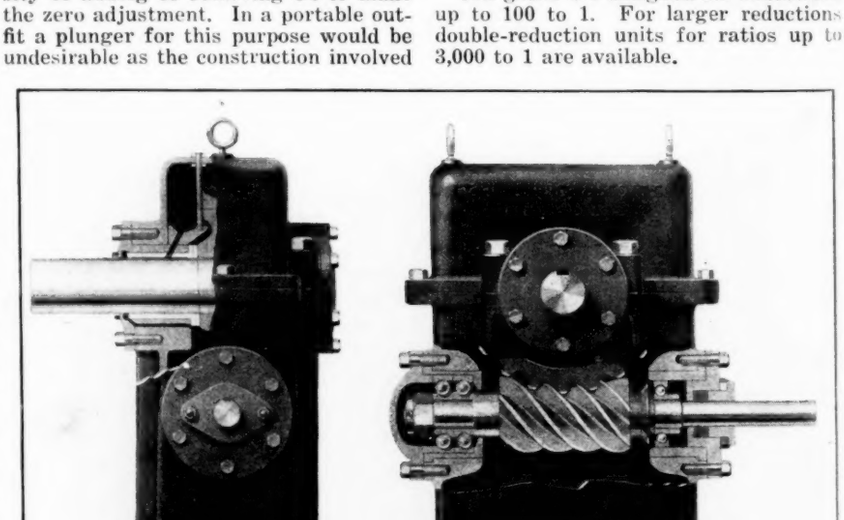
In the illustration two of the inclined-type draft gages are shown to illustrate how the gage may be mounted to a wall with the knurled screw which is furnished, or placed on a flat surface and leveled with the micrometer screw on the detachable supporting foot. The gage has been placed on its leather containing case. A feature of the gage is an adjustable scale, obviating the necessity of adding or removing oil to make the zero adjustment. In a portable outfit a plunger for this purpose would be undesirable as the construction involved would be conducive to leakage. In this same connection a special needle valve to lock the oil in the oil well has been provided to prevent loss of oil during transport.

Horsburgh & Scott Worm-Gear Speed Reducer

A line of speed-reduction units made in three types has been brought out recently by the Horsburgh & Scott Co., Cleveland, Ohio. Type B, in which the worm is below the gear, is illustrated. The other types are T which has the worm above the gear, and Y which has the gear shaft vertical.

The worm, which is integral with the shaft, is made from a solid forging of special low-carbon steel, casehardened and ground all over, including the thread surfaces. The wormshaft is mounted on ball bearings, the rear bearing being of the duplex radial thrust type. The gear is made of special gear bronze. In the smaller units the entire gear is bronze, while in the larger units the bronze ring is shrunk on a cast-iron hub and secured by riveted pins. The size and mounting of the gear shaft is determined by the character of the service on which the unit is to be used. In some cases a lighter shaft mounted on either ball or roller bearings is suitable, while for overhung loads a heavier shaft and bronze journal are employed as illustrated, and for particularly severe service an extra large gear shaft can be furnished.

The gears are designed for reductions up to 100 to 1. For larger reductions double-reduction units for ratios up to 3,000 to 1 are available.



Type B worm-gear speed reducer

The New Hays Pointer Draft Gages

In the new line of pointer draft and pressure gages developed recently by the Hays Corporation, of Michigan City, Ind., an outstanding feature is the extreme simplicity of the operating mechanism, which consists essentially of a slack leather diaphragm, a phosphor bronze cantilever spring and a pointer mounted on a pivot bearing, which is attached to the spring by a nickel-silvered bead chain. The arrangement is shown in the sectional view, Fig. 1.

The diaphragm is a pliable, tough, gastight animal membrane which the Bureau of Standards has found to be ideal for this service. The diaphragm merely transmits the force of the draft or the pressure to the flat bronze spring, which in turn moves the counterweighted pointer on its pivot and thus

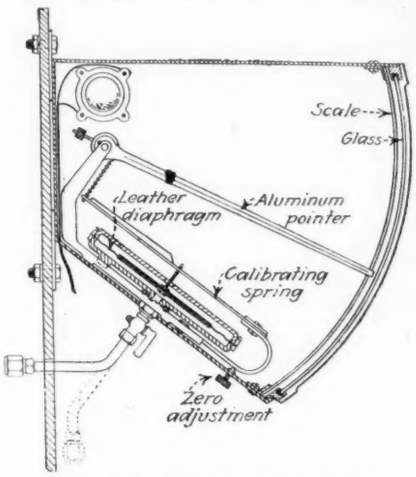


Fig. 1—Section of gage showing operating mechanism

produces a reading on the scale in direct proportion to the magnitude of the force acting upon the diaphragm. The area of the leather diaphragm as compared to that of the inlet tube is large, so that the draft action is greatly magnified and a comparatively powerful force acts upon the spring. As shown in the drawing, the latter is held rigidly at one end and its movement is well within the elastic limit, so that the gage should hold its calibration indefinitely.

It will be evident that the position of the spring determines the position of the pointer and the spring is moved in proportion to the magnified force applied through the diaphragm. The movement is smooth and deadbeat so that there is no occasion for dashpots or dampeners.

Zero adjustment is necessary only when the gage is first mounted in position. By means of the micrometer screw shown, the entire mechanism is tilted until the arrow points to zero and thereafter the zero position of the pointer does not shift. As the gages do not need to be leveled they are easily mounted in the power plant, and are well suited for testing work where portability and quick set-up are desired.

The gages are made in two types. Where one or two scales are required, type F, shown in Fig. 2, is recommended, but where a number of pressures have to be read simultaneously, as in the control of mechanical stokers using forced draft, type V, shown in Fig. 3, is the instrument used. Any desired number of these instruments may be grouped in a single casing to meet the requirements of an individual

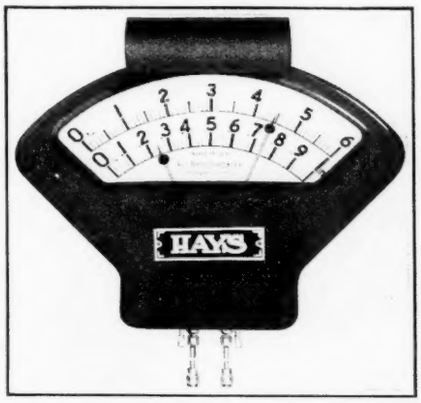


Fig. 2—Type F-2 double-scale draft gage

plant. In either type the principle of operation is the same, the only difference being in the arrangement and the casing.

All gages are direct reading. They can be calibrated for a total scale range of ¼ in. water draft up to 30 in. of water pressure, and any differential range within these limits can be handled for either draft or pressure. Except in meters having a positive and negative range, the zero is at the bottom of the scale. This facilitates reading where a number of pressures have to be taken simultaneously, as in the control of mechanical stokers using forced draft or where the stoker wind box is divided into a number of compartments.

In the V-type gages scales measuring 12 in. long and 2½ in. wide are provided with large plain black figures.

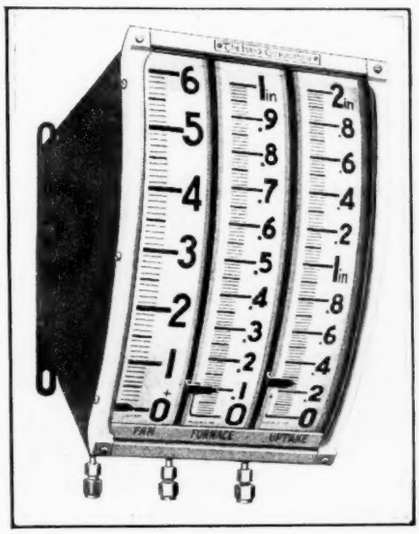


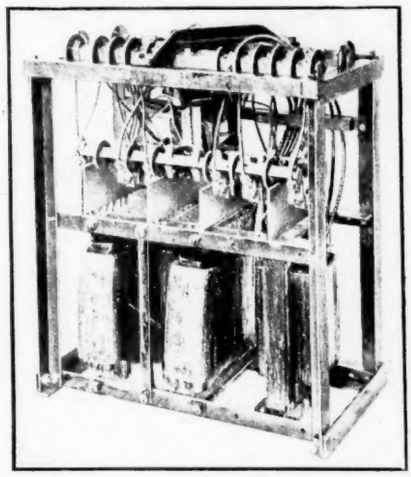
Fig. 3—Three-scale gage of the V-3 type

Bright red indicating arrows and a translucent, illuminated celluloid scale of long radius improves the visibility so that readings may be taken from distances of 50 to 100 ft. and over a wide angle of vision. The cases are moisture and dust-proof, and aluminum covers are used to protect the leather diaphragm.

Automatic Synchronous-Motor Control

A completely self-contained, oil-immersed automatic starter for 2,300-volt synchronous motors has been developed by the Electric Controller & Manufacturing Co., Cleveland, Ohio. This is built for across-the-line starting of slow-speed motors and for reduced-voltage starting of the higher-speed motors. The figure shows a reduced-voltage starter with the case removed. In each case the operator simply pushes a button to start the motor and as the motor approaches synchronous speed, the field excitation is automatically applied.

The reduced-voltage starter consists of a welded boiler-plate tank that contains an automatic double-throw switching mechanism, a power transformer for providing starting voltage, potential transformers for providing 220 volts for the master-switch operat-



Starter with cover removed showing transformer coils and switching mechanism

ing current, and the current-limit transition relays, which connect the motor to full voltage when it has been accelerated to approximately 85 per cent of synchronous speed.

On the outside of the tank there is a dustproof steel cabinet which incloses a field-switching mechanism, field-discharge resistor, timing relay and direct-current field ammeter. This cabinet may also contain an automatic starter for operating a magnetic clutch or other auxiliary control.

The full-voltage starter is of similar construction except that the starting auto-transformers are omitted. This equipment is complete in a single unit. It makes possible the floor mounting of all the equipment necessary for starting synchronous motors.

Vibration in Hydraulic Turbine Machinery*

Results of Investigations Made to Determine the Cause of Vibration in Hydraulic Turbines Under Various Conditions—Remedies for Some of These Troubles Are Suggested

HYDRAULIC vibration may be roughly classified as follows:

PERIODIC VIBRATIONS (25 TO 400 CYCLES PER SECOND)

(a) Cause
1—Pressure reaction.
2—Close clearance and high specific speed.
3—Runner and guide vane combinations.
(b) Effect
1—Weakening of structures.
2—Weakening of penstocks.
3—Pitting (incidental in design).
4—Loss of efficiency.

NON-PERIODIC VIBRATIONS DUE TO FLOW CONDITIONS

(a) Cause
1—Draft tube surges.
2—Air.
3—Extreme variations in head.
(b) Effect
1—Penstock breathing.
2—Major shocks or pounding.
3—Bearing trouble.

VIBRATIONS DUE TO MECHANICAL UNBALANCE

(a) Cause
1—Ususally caused by blocking part of runner with foreign material.

PERIODIC VIBRATIONS

Under this heading are grouped those effects due to the fundamental runner design of reaction turbines.

One of the inherent characteristics of a reaction turbine is that the pressure on the leading side of the runner inlet should be higher than that on the trailing. It is usually the case that the pressure at the top of a vertical turbine runner is higher than the simultaneous pressure at the bottom (see sketch).

On a turbine in operation it is possible and practicable to explore the whole face of the runner inlet, giving a family of curves similar to those shown. (See *Transactions* A.I.E.E., 1923, page 1001.) On the several turbines thus explored this difference in pressure varies from as high as 15 per cent of the head to only 4 or 5 per cent.

This variation in pressure presents to the incoming flow a varying back pressure like teeth of a gear, and this results in a change of velocity of the incoming water. Different combinations of guide and runner vanes cause different combinations of these impulses to show in the scroll case and penstock; those in which the individual impulses add being the most severe. Certain combinations of the number of guide and runner vanes tend to neutralize by virtue of their different phase, and so make a comparatively quiet running turbine even though the reaction is high.

Clearance between the runner and guide vanes interposes between the runner and the entering water, a ring of water serving as a sort of buffer or equalizer for the pressure variations presented by the runner inlet. On turbines in use it will sometimes materially decrease the vibration and increase the efficiency to cut back the runner inlet arbitrarily and increase this clearance.

On such machines as have been examined the shape of the guide vanes and the thickness of the runner vanes apparently have very little effect on this type of vibration.

The effect of such continued vibration is not known except that any vibration at such frequencies is felt to be detrimental to both concrete and metal subjected to it. The loss in efficiency, while usually not great, is apparent on a careful test.

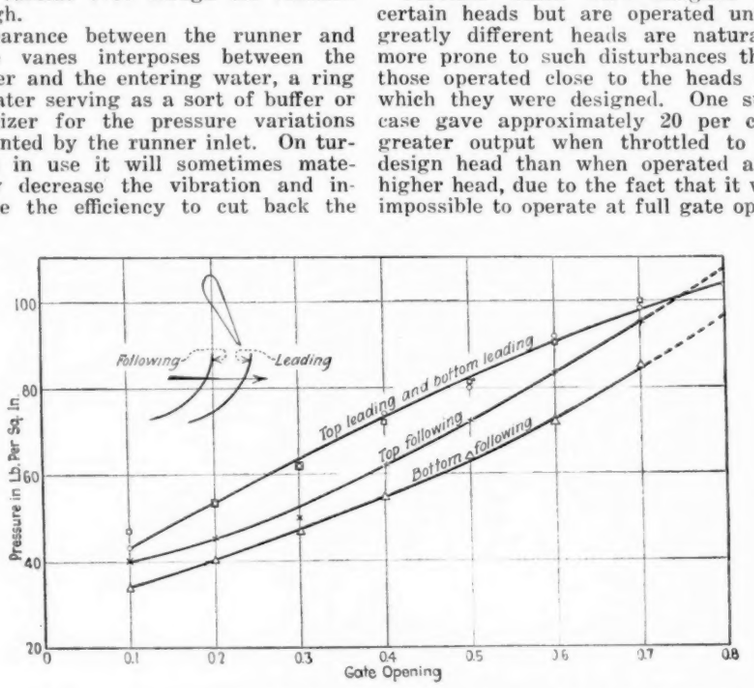
NON-PERIODIC VIBRATIONS

This type of vibration manifests itself by thumping or sudden pressure changes and may be as high as 20 to 30 per cent of the total head, though usually much less, and it causes rather severe disturbances.

In the turbines tested there was a residual whirl in the water in the draft tube which reversed at some critical point in gate opening. In most turbines the flow through the draft tube is not uniform and may in certain parts of the draft tube at some loads reverse and flow toward the runner.

These changes in direction cause sudden breaks in all or part of the vacuum in the draft tube, with a resulting slap of the water against the runner or other surfaces, or against other portions of water, which result in a sort of water hammer apparent as a sudden pressure rise through the turbine and back up the penstock. These pressure rises are usually too sudden for the average pressure gage to record. In the penstock these pressure rises are damped and lengthened, and are apparent as a sort of breathing action. Air in the water in any considerable quantity causes sharp cracking noises as it expands in the draft tube and corresponding sharp pressure rises.

Turbines which were designed for certain heads but are operated under greatly different heads are naturally more prone to such disturbances than those operated close to the heads for which they were designed. One such case gave approximately 20 per cent greater output when throttled to its design head than when operated at a higher head, due to the fact that it was impossible to operate at full gate opening on the higher head on account of vibration. In this case the throttling was accomplished by partly closing the penstock valve, which was of the butterfly type. (See *Transactions* A.I.E.E., 1923, page 1002.)



Pressure at runner inlet for different gate openings of vertical Francis turbine

VIBRATIONS DUE TO MECHANICAL UNBALANCE

The third type of vibration is usually so pronounced that it is impractical to run with the runner openings blocked, and in most cases it is so apparent that immediate shutdown is necessary. Such unbalance is apparent once per revolution, and has not the sharp impact characteristics of the other two types.

GENERAL CONSIDERATIONS

The subject is too extensive and too little is known about it at the present time to lay down either general methods or results. Most investigations have stopped as soon as something was discovered which would allow reasonable operation, and nothing further done until other trouble occurred.

Intimately connected with all of these vibration troubles are difficulties due to pitting caused by the fact that in a mixture of air and water under pressure oxygen is absorbed by the water which on its way through the runner loses its pressure and consequently frees oxygen in an active state. This oxygen attacks metal at any point where the water leaves the metal, so

*Abstract of the National Electric Light Association's Hydraulic Power Committee's Report, presented at the 49th Convention held in Atlantic City, N. J., May 17 to 21, 1926.

that any curve in the runner vane not filled entirely with water will have a pocket of oxygen next to the metal. This fact can be demonstrated by placing a metal sheet with a little hollow spot in it so that a jet of water under pressure plays across it, leaving the hollow spot under the jet. With a fairly high pressure and a considerable air content in the water the action is comparatively rapid. Pitting has been observed wherever there is a sudden pressure change with a chance for the active gas to collect.

Not all turbines troubled with vibration are subject to pitting or vice versa, but the causes are much the same, so far as the tests to date indicate, modified, of course, by runner and guide vane combinations, etc. With the equipment now used it is possible to explore any part of the turbine runner for both instantaneous and effective pressure.

In the foregoing very little has been said regarding impulse wheels for the reason that from the very nature of the case very little such trouble is ever encountered. The jet, after it leaves the nozzle, is free and communicates nothing back to the penstock that happens in the wheel. Impulse wheel vibration so far encountered has been purely mechanical and easily explained.

Negligent Operation of Boilers

By Arthur L. H. Street

In the case of Miller vs. Harris, 281 "South Western Reporter," 907, lately before the Arkansas Supreme Court, judgment in favor of Harris, plaintiff in a lower court, on account of injury sustained in explosion of a boiler he was firing, was affirmed.

The suit was grounded on negligent failure of the defendants, employers, to provide an injector and a fusible plug in good order. The employers unsuccessfully sought to avoid liability on the grounds that the plaintiff assumed the risk of injury involved in continued firing of the boiler with knowledge as to the condition of the injector and that except for the fact that he went to sleep on duty the explosion would not have occurred.

Plaintiff's evidence tended to show that he had been employed by defendants for but about eight or nine weeks before the accident; and that he had complained of the defective condition of the injector and had been assured that it would be either repaired or replaced. The pump used to force water into the boiler, in lieu of the injector, was in good order, and plaintiff knew that unless the boiler was closely watched it might explode. There was a soft plug in the crown sheet, but it was found to have been corroded an inch thick, thereby preventing melting.

Defendants' testimony conflicted with plaintiff's as to the condition of the injector and as to his having made complaint, or having received any assurance concerning it. They claimed that the explosion resulted from plaintiff's going to sleep and permitting the water to get below the crown sheet.

Concerning the employers' claim that plaintiff assumed the risk of operating the boiler without an injector, the Supreme Court said:

"In the first place, the jury may have believed his statement to the effect that he continued to operate the boiler without an injector in reliance upon appellants' promise to repair it or get a new one; and, in the second place, the jury may have believed the testimony of appellants (the employers) to the effect that the injector was attached to the boiler, and that of appellee (plaintiff) to the effect that the injector was out of repair. It was not claimed by appellants that there was any special danger incident to operating the boiler without an injector, which was . . . obvious. On the contrary, they claim there was no more danger in putting water in the boiler with a pump than with an injector in good repair. It is true that an employee assumes the dangers incident to his employment, and especially those which are . . . obvious, but he does not assume results from mistakes in judgment. The record reflects that an exercise of judgment was required when putting water in the boiler with a pump, but none was required when putting it in with an injector."

Concerning the employers' further contention that the explosion occurred because of plaintiff's own negligence in permitting the water to get below the crown sheet, the Supreme Court added:

"This position is assumed upon the ground that it was appellee's duty to keep enough water in the boiler to prevent an explosion, and that, when water was kept above the crown sheet, all danger of explosion was eliminated. Appellee testified that in operating the boiler experience had shown it was necessary to put water in the boiler every 10 or 15 minutes, and that he put a sufficient amount of water in the boiler to run it beyond the time it exploded about 10 minutes before the explosion occurred. . . . The conflicting testimony made the question of whether appellee was guilty of contributory negligence one for the jury to determine."

Life of Generator Insulation

An inquiry has been made to determine the practice with respect to testing, maintenance and replacement of generator insulation, by the N.E.L.A. Electrical Apparatus Committee.

Of the companies reporting on voltage tests, 14 use the A.I.E.E. standard, 3 use three times normal and 11 use lower tests than A.I.E.E. standard. A number of companies reported using 150 per cent normal voltage for routine tests after installation, these tests being made for the most part at regular intervals, varying from three months to one year; 28 companies rely upon megger tests, some of them using these tests only as an indication of dryness after installation; 31 companies revarnish regularly, 16 do not. The majority believe in revarnishing sooner or later.

Forty-two companies reported that they do not reinsulate after a certain period of service before failure; 16 companies do reinsulate before actual failure if tests indicate extensive deterioration.

One hundred and forty failures were reported, of which 55 were due to mechanical and 85 to electrical causes. Half the failures occurred on steam-driven units, 68 on water-driven units and 2 on frequency converters. The information as to the class of insulation used on the machines which failed was so scanty as to preclude the forming of definite conclusions.

Considerable difference of opinion appears in the estimates of the "safe operating life" of a high-voltage generator's insulation. For "Class A" the estimates range from 7.5 years to 12 years, for "Class B" from 8 to 30 years. The consensus of opinion would seem to be 10 years for the former and 12 for the latter. The life of insulating material depends upon so many factors entirely beyond control, that it is well-nigh impossible to make any definite statement as to the expected life without laying down a set of controlling conditions.

Preventing Sludging of Transformer Oil

The formation of sludge in oil-immersed transformers has reached such serious proportions on some power systems as to affect adversely the operating performance and possibly the life of the insulation. One of these companies, making an investigation among a small number of other companies, came to the conclusion that the amount of sludging in the open type of transformer has greatly increased in recent years, and that this increase can generally be attributed to higher operating temperatures, longer and heavier load periods, and in some cases to over-excitation. A canvass of the country by the subcommittee of the N.E.L.A. Electrical Apparatus Committee confirmed this conclusion.

From information furnished, it shows rather conclusively that where means are taken to prevent the oxidizing reaction of the oil by sealing against air contact, or the use of low operating temperatures and normal excitation, no appreciable amount of sludge will form. If the open-type transformer is still to be installed in proportion to the number now in service and operated at temperatures permissible under the present standards or over-excited, the only alternative to avoid sludging appears to be the improvement of the oil to a non-sludging value or a change in the method of cooling the oil that temperatures may generally be lower.

Statement and Engineering Report by the Hydro-Electric Power Commission of Ontario Submitted to the International Joint Commission Respecting the Proposal to Develop the St. Lawrence, 1921. This report has been published in a limited edition for reference libraries and public officials especially interested in the subject of the development of the St. Lawrence River for navigation and power. A limited number of these reports with the accompanying elaborate colored plates of plans can be secured from the Hydro-Electric Power Commission of Ontario, 190 University Ave., Toronto, Canada, for $7.50.

Nations Honor John Ericsson, Man of Vision

Sweden and America Join in Tribute to Inventor at Unveiling of Memorial Monument at Washington

WITH the birth of John Ericsson at Langbanshytten, in a remote section of Sweden, on the last day of July, 1803, a new vision of steam as a power and its importance to navigation may be said to have come into the world. With untiring energy and application the boy spent his formative years in a gruelling study of mechanics and mathematics. His father a miner and teachers lacking within the vicinity of his home, he had his early education from the lips of his mother, a woman of remarkable qualities and perception. But the child himself was father to the inventor. He set himself questions and sought their answers, and of difficult problems he labored over the solution unaided. We have good reason to suppose that from this period on Ericsson labored more with the view toward fundamental discernment in what later developed as his chosen field, than he gave time or thought toward immediate exploitation. When his inventions were realized, they were, primarily, the achievements of his vision.

Early Training

The fortunes of the Ericsson family were greatly diminished by the Russo-Swedish war over Finland, and in 1811 the father sought employment on the Gota Canal, the largest engineering venture then being undertaken in Sweden. Finding himself, at the time hardly in his 'teens, surrounded by the stimulating atmosphere of the work, the boy rapidly skilled himself in draftsmanship, a science in which he remained an expert until his death. In a moment, it seemed, he was chief leveler for the development. By another year he had been placed as a cadet in the mechanical corps of the navy. But he soon joined the Field Chasseurs of Jemtland, and gave his time to a study of artillery.

While thus obtaining a broad and thorough training, the youth was hard at work fashioning the first model of his flame engine. News of it reached the Court, and soon he was on his way to England on the suggestion and aid of the King, who strongly advised English cash and English opportunity for the furtherance of his talents.

With Braithwaite

True to the course of genius, Ericsson met with trying disappointments on his arrival. Owing to the difference in the fuel he was now obliged to use, the development and recognition of his flame engine was beset with difficulties. Soon, however, he became known to John Braithwaite, "builder of machines." A partnership ensued shortly. From that day each month was fraught with plans diligently executed. With heads and hearts as one, the partners added invention after invention to their credit. Foremost in importance among these was a water pump driven by compressed air.

Tubular Boiler

And now, the result of painstaking observation and experiment with thought of the need for greater power development, Ericsson saw the possibilities that lay in the further and more efficient harnessing of steam. "Steam" and "navigation" he had already linked together. The boiler fires of those days were temperamental. They burned or went out at will. Applying the principle of artificial drafts and a cleverly constructed tubular boiler, he found a solution. Surface condensation followed. Both of these inventions featured in the construction of the "Victory," the first ship run by machinery below the water line.

All who are familiar with the history of railway development can recall the story of the race between Ericsson's steam engine, the "Novelty," and Stephenson's "Rocket." A Liverpool and Manchester company, owning a line running between the two cities, called for a performance of an engine drawing twenty tons, itself weighing less than seven. It was reported that the "Novelty" shot by the "Rocket like a projectile.

Turning his attention again to the sea, Ericsson devoted the maturity of his years to the consideration of the utmost application of power in navigation. Submerged propellers occupied his whole thought for the year 1833. A few years later he met in Liverpool, Francis B. Ogden, United States Consul. Acclaimed already by a few scientific men of two countries, a third, the United States, soon sought the aid of his genius. Through Ogden the inventor met Robert F. Stockton, of the United States Navy. The Admiralty and the British naval engineers had not recognized the value of his screw propellers, but his ideas were instantly appreciated by the Americans. A small boat constructed with his latest equipment stood well the trial test on the Thames.

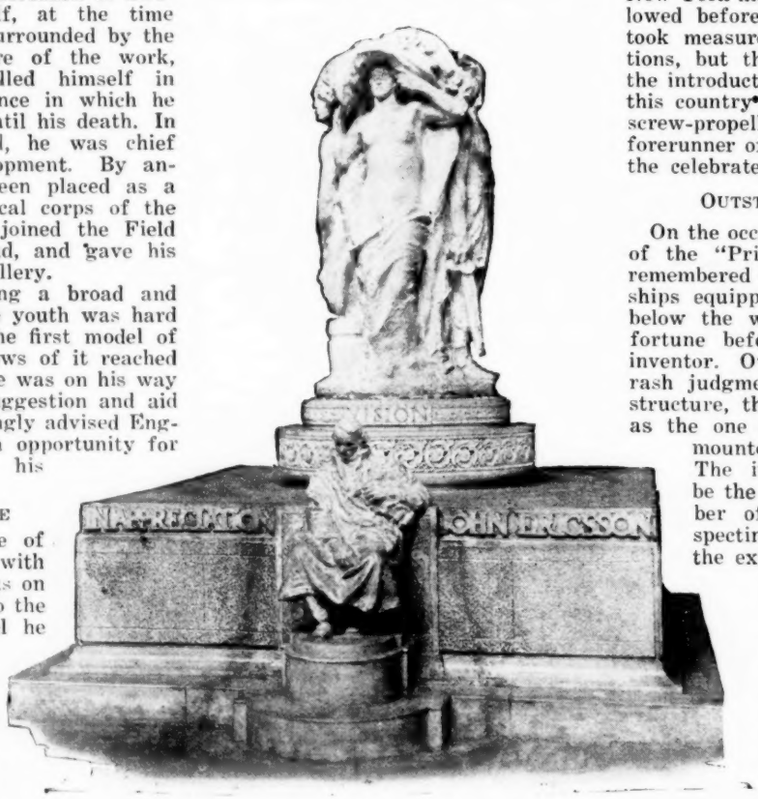
First Screw Propeller

This success resulted in an order from the United States for a small iron vessel fitted by Ericsson with engines and propellers. The ship reached New York in the fall of 1839, and a few months later her progenitor arrived to make New York his home. Many months followed before the government actually took measures to forward his innovations, but this period was fruitful of the introduction of his steam engine in this country and the construction of a screw-propeller warship, in type the forerunner of "the Monitor." This was the celebrated "Princeton."

Outstanding Inventions

On the occasion of the formal testing of the "Princeton," which should be remembered as the first of modern warships equipped with power machinery below the water line, a serious misfortune befell the reputation of the inventor. Owing to Captain Stockton's rash judgment, a gun of too massive structure, though of the same caliber as the one ordered by Ericsson, was mounted and fired from the deck. The intended salute proved to be the hand of tragedy. A number of sailors and several inspecting officials were killed in the explosion. For several years the name of the inventor was overcast.

A great number of inventions now crowded his years until the outbreak of the Civil War. From both their striking novelty and value they left a permanent foundation to his fame. In addition to the screw propeller were a steam boiler of artificial drafts which dispensed



The John Ericsson Memorial Monument at Washington
James Earle Fraser, Sculptor

with smokestacks and effected an important saving in fuel; a steam fire engine; the caloric engine; a sliding telescope chimney; machinery to check the recoil of heavy guns; an instrument for measuring distance at sea; the hydrostatic gage for measuring the volume of fluids under pressure; a meter to measure the volume of water passing through pipes; an alarm barometer; a pyrometer to measure temperature from the freezing of water to the melting of iron; a lead to take soundings without rounding the ship to the wind; and various modifications of the caloric engine in which the expansive force of hot air was used as a source of power.

The success of the caloric engine brought the immediate support of the King of Sweden and recognition throughout the leading countries of Europe. Simultaneously prominent men of New York financed the building of the "Ericsson," propelled by paddle wheels operated by a caloric system. Unfortunately, the vessel was lost on her second voyage.

"Monitor" vs. "Merrimac"

Disaster in the shape of the far-famed "Merrimac" overtook Union shipping during the first year of the Civil War. One by one this crude, iron-sheathed monster of the Confederate forces floated down on United States ships entering Hampton Roads. The timbersides of the Union Navy were no match for the ironclad. The Administration considered the situation desperate. Ericsson was summoned to Washington. The keel of the "Monitor" was laid Oct. 25, 1861; she was ready for action Jan. 30, 1862. Two days after leaving New York Harbor she gave battle to the "Merrimac."

"The cheese box on a raft" proved more than the equal of her larger opponent. From the single revolving turret amidships the gunners gave as well as they took; in fact they gave more. The smooth turning turret presented a poor mark as it fired at the bulky sides of the "Merrimac." Then, too, she rode low in the water, her deck often covered by the waves. Finally disabled by a well-aimed shot, she withdrew to shallow waters unbeaten and beyond pursuit. But the dread of the "Merrimac" was shattered.

Life Given to Work

Much has been said of the patriotism of Ericsson for his adopted country. That he chose the United States for the furtherance of his inventions and the prosecution of his discoveries is certain, and that he gave to this country liberally and unquestioningly is equally evident. But that, as the common belief runs, he took a very personal interest in the Civil War, or in any country, in fact, is highly improbable. He was mated to his science from his birth to his death. Toward the close of his life honors were showered upon him. Invited by the Crown Prince to visit the country of his birth, and later requested by the Department of State to attend as Commissioner the Universal Exhibition held at Paris, Ericsson declined, finding his experiments at home more absorbing. Rather than a patriot of either country, he was a builder of all time.

A true and active scientist and inventor till the end, he died in New York, where he had always lived since his arrival in the United States, on March 8, 1889. At the request of Sweden his body was returned to find a last resting place at Filipstad, in the locality of his birth.

Memorial Ceremony

Under the auspices of the American Society of Swedish Engineers the unveiling of a memorial statue to John Ericsson, erected on the Mall in Washington, took place on May 29, with leading personages of Sweden and America paying tribute to his achievements. President Coolidge, the Crown Prince and Princess Louise, Secretary Hoover, the Swedish Ambassador, ranking officers of the United States Navy and many eminent engineers of both countries gathered for the ceremony.

Situated near the Lincoln Memorial, the granite monument presents a striking though dignified appearance. Its main execution is symbolical. The inventor is seated at the base. Above him are grouped figures personifying Vision, Adventure and Labor. Of masterful mien, these appear to keep the watch over him, as he sits wrapt in meditation. James Earle Fraser is the sculptor.

Unveiled by Prince

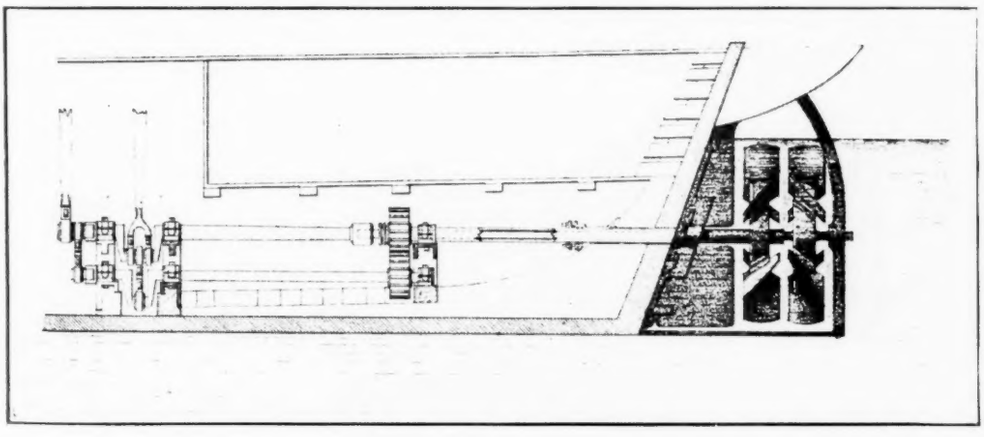
Owing to unfortunate delays in the progress of the work, the finished monument could not be got ready for the date scheduled for the unveiling. Parts of the basic pedestal and much in the details of the figures grouped above the seated inventor are still unfinished. In their place carefully made models were substituted for the occasion, as it was impossible for the royal party and the large body of visiting delegates from the Swedish engineering and scientific societies to longer postpone their return to Sweden.

A United Tribute

Himself unveiling the monument, the future King of Sweden gave a short expression of his appreciation of the friendly union between Swedish and American engineers and scientists, stating that on such an occasion as this the homage given to the great inventor by representatives of both countries meeting jointly was a significant proof of the friendly spirit existing between the two peoples.

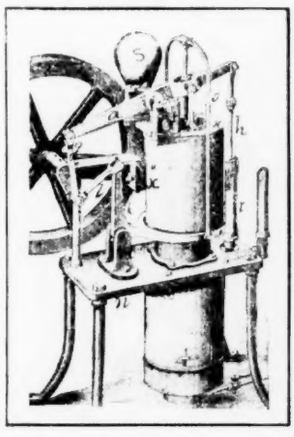
Banquet

In close connection with the unveiling in the afternoon, a banquet was held in the evening in the ball room of the Hotel New Willard, under the joint auspices of the American Society of Swedish Engineers and the Swedish Engineering Society of Chicago. The feature event of this session was the awarding of the John Ericsson Medal to Dr. Svante Arrhenius. Presented by Eric A. Lof, president of the American Society of Swedish Engineers, an official delegate received the medal for Dr. Arrhenius, who, due to illness, was unable to attend. Dr. Arrehenius, considered the father of electro-chemistry, was unanimously chosen as the first recipient of the award. He did much toward establishing the theory of the relations of the electrolytic phenomena to the chemical properties of substances.



An interesting section of the "Princeton," the first steamboat using under-water propellers

This iron frigate was constructed in 1842, driven by the inventor's twin opposed propellers directly connected to the two steam engines. This was also the first vessel in which the engines drove the propelling mechanism directly.



Caloric Engine

This hot air engine was later redesigned and widely sold.

News in the Field of Power

Arizona Asserts Tax Right on Colorado Power Project

Abandoning its plan to proceed with the consideration of the Swing-Johnson Boulder Dam bill in its executive sessions, the House Irrigation Committee has agreed to reopen hearings for a statement from Dwight B. Heard, editor of the Phoenix, Ariz., *Republican*, who was a candidate for Governor in 1924 as an advocate of the Colorado River compact.

The decision to reopen hearings was made in the face of opposition from Representative Swing (Rep.), of El Centro, Calif., and Representative Arentz (Rep.), of Simpson, Nev., who urged that the committee continue its executive sessions until the bill is finally disposed of.

Royalty Tax Just

Mr. Heard asserted the rights of Arizona to use of the waters of the Colorado River and to impose a royalty tax on projects in Arizona where the usufruct shall extend to neighboring states. He urged that a tri-state treaty among Arizona, California and Nevada, covering the right of Arizona to impose such a tax, be entered into and agreed to by Congress as preliminary to legislation for development projects, and also maintained that the United States should meet the expense of flood control as its part of the cost of the undertakings.

Friendly Negotiation

The committee was further informed that Arizona proposes to protect its rights in the waters of the Colorado River, if necessary, by legal process. He declared, however, that Arizona preferred to solve this problem by friendly negotiation of a just arrangement, asserting that the viewpoint of Arizona has been accepted by California interests.

Under an informal agreement reached at the session, it is expected a commission appointed by Governor Hunt, of Arizona, who defeated Mr. Heard by urging that the Colorado compact be not ratified, will appear before the committee next week. Word that such a commission is on its way to Washington has been received by the committee.

A Grave Injustice

The charge that Arizona is being done "a grave injustice" by the proposed location of the Colorado River Dam at Boulder was made on the floor of the Senate, May 17, by Senator Henry F. Ashurst, Arizona, Republican.

Senator Ashurst charged that, when the Senate Irrigation Committee made the authorized inspection "on the ground," only Senator Wesley L. Jones, Republican, Washington, visited the other site, 90 miles above the Boulder.

"To place the dam at Boulder will be to waste one-third of the potential horsepower," he said. "If the dam is placed 90 miles above its proposed location, it will not only generate approximately 50 per cent more horsepower, but the City of Los Angeles can be supplied with more water than it needs by gravity."

Council Undertakes Survey On Safety and Production

To check the mounting number of industrial accidents a "safety and production study" has been started by the American Engineering Council, it is announced here by the president of the Council, Dean Dexter S. Kimball of Cornell University.

"The results of this study, which aims to determine whether there is a definite correlation between safety and production, that is, whether the safe factory in general is the productive factory and vice versa, are expected," Dean Kimball said, "to hasten a new era of industrial safety in this country.

"In spite of fifteen years of highly effective work in the safety movement, the number of industrial accidents in general still seems to be increasing, a result that is due apparently to the increasing mechanization of industry.

"Some means of getting an effective control of the situation must be found. Industry can and must devise ways to carry its operations on more safely."

Arthur W. Berresford, Detroit electrical engineer, who during the war was chairman of the General War Service Committee of the electrical manufacturing industry, has been named chairman of the committee of the American Engineering Council which will direct the survey. Leon P. Alford, of New York, who was a member of the Hoover Waste Committee, is vice-chairman.

A group of field engineers will work in the important industrial centers of the country under the direction of Joshua Eyre Hannum, of New York, research engineer of the Eyesight Conservation Council of America.

Chicago A.S.M.E. Holds Election of Officers

Officers to head the Chicago A.S.M.E. for the ensuing year were elected at the last meeting of the season held at the City Club, May 12. Following an excellent entertainment program, Robert Kingery, secretary of the Chicago Regional Planning Association, gave an interesting paper on "On Regional Planning."

Those elected for the coming year are: Col. Hugo Diemer, chairman; Thomas Wilson, vice-chairman; Fred B. Orr, secretary and treasurer; Robert R. Keith, R. H. Bacon, M. J. Evans, and J. I. Banash, executive committee.

Boulder Dam Bill Tabled For Next Session

All probability of advancing further the Boulder Dam legislation at this session of Congress vanished when the House committee on Irrigation and Reclamation voted recently to table the revised Swing-Johnson bill. The so-called power amendments prepared by Representative Leatherwood, of Utah, were withheld until the time should be more propitious for their formal presentation.

The Irrigation committee devoted practically all of its time at this session of Congress to the consideration of the Boulder Dam question. Finally, it became clear that no agreement could be reached. This led Representative Hayden, of Arizona, to offer the motion to table. The vote on the motion was nine to six. Representatives Leatherwood and Allen, of Illinois, Republicans, joined with the seven Democratic members of the committee in supporting the Hayden motion. Those voting against the motion were: Chairman Smith, of Idaho; Swing, of California; Leavitt, of Montana; Arentz, of Nevada; and Winter, of Wyoming.

Westinghouse Building Plan Calls For $5,525,000

The present building program for the expansion of facilities at various plants and offices of the Westinghouse Electric & Manufacturing Co., will involve an expenditure of $5,525,000, according to T. P. Gaylord, acting vice-president of the company.

New factory structures of office buildings are now in course of construction at East Pittsburgh, Pa., headquarters of the company, and at Mansfield, Ohio, Detroit, St. Louis, East Springfield, Mass., Sharon, Pa., and Derry, Pa.

The cost of the new general office building now nearing completion at the East Pittsburgh works is $1,500,000. The structure is 11 stories high, with a floor area of 165,000 sq.ft. This space is designed for the accommodation of 1,800 employees. The building is scheduled for completion this summer.

Reclamation Power Aids Idaho Farmers

Approximately half the 2,500 farm homes on the Minidoka irrigation project in southern Idaho are supplied with electric energy which cheaply and efficiently aids the farmer and his wife in their daily tasks, acording to a statement issued May 24 by the Department of the Inteior.

In summer the greater part of the energy produced in the project power plants operated by the Bureau of Reclamation is used in pumping water for irrigation, but the project commercial and domestic load is also handled.

Ambrose Swasey Given Testimonial Dinner

Ambrose Swasey, past-president and honorary member of the American Society of Mechanical Engineers, was the guest of honor at a testimonial dinner tendered by the Cleveland section of the A.S.M.E. at the Hotel Cleveland, Cleveland, Ohio, on May 14, 1926.

Charles F. Brush, pioneer electrical inventor, presided. The principal address of the evening was delivered by Dexter S. Kimball, Dean of the School of Engineering, Cornell University, past-president of the A.S.M.E. and president of the American Engineering Council. In his address, which was a splendid tribute to a great inventor, engineer and friend of science, Dean Kimball told of the deep appreciation in which Mr. Swasey was regarded, not only because of his achievements, but also for his uncommonly fine friendliness. In his response Mr. Swasey showed how deeply touched he was by this testimonial from his friends and fellow-citizens of Cleveland.

J. Rowland Brown, chairman of the Cleveland section, read a large number of messages from eminent scientists, engineers and industrialists. James H. Herron, chairman of the committee in charge of the dinner, then presented Mr. Swasey with a testimonial bound in leather and signed by those present at the dinner.

Rogue River Survey Finds Great Potential Power

The potential power of Rogue River, Oregon, and its principal tributaries under the natural flow is 514,000 hp. for 50 per cent of the time and 202,000 hp. for 90 per cent of the time, and by the construction of four reservoirs these figures could be increased to 532,000 and 429,000 hp., according to a statement just issued by the Department of the Interior through the Geological Survey. There are eight water-power plants in this basin, but the combined capacity of the installed machinery is only 13,000 horsepower.

Rogue River's source is on the slopes of the old volcano, collapse of which formed the basin now occupied by beautiful Crater Lake. This volcano during its last eruption sent forth a great volume of volcanic dust which covered the country round about to a considerable depth. The heavy rains of the winter easily percolate into this light material and then, flowing slowly as underground water, do not reach the river until the following summer. This underground storage gives to Rogue River and other streams heading in the same area a well-sustained flow throughout the year, a great asset to water-power plants.

Correction of Error

Owing to last-minute pressure in reporting the N.E.L.A. convention last week, omission of the following change of office was unavoidable: Percy S. Young, vice-president of the Public Service Electric & Gas Co., of Newark, N. J., became treasurer, succeeding W. A. Jones.

Ericsson Medal Honors Dr. Svante Arrhenius

Further signifying the memory of John Ericsson, the first award of the gold medallion founded last year as the John Ericsson Medal was conferred on Dr. Svante Arrhenius, Swedish scientist, by the Amercian Society of Swedish Engineers at a formal presentation ceremony held at the Hotel New Willard, Washington, D.C., on the evening of May 29.

Following the unveiling of the memorial statue to Ericsson, erected on the Mall, which took place at 3 o'clock in the afternoon, attended by the Crown Prince of Sweden, Princess Louise, President Coolidge, the Swedish ambassador, ranking officers of the Navy and many distinguished persons of both nations, the event of the presentation was signalized by a dedication dinner under the joint auspices of the American Society of Swedish Engineers and the Swedish Engineers Society of Chicago.

Dr. Svante Arrhenius

Due to illness Dr. Arrhenius was unable to be present. Accordingly, Eric A. Lof, president of the society, tendered the medal through Mr. Enstrom, one of the official delegates from Sweden and a personal friend of the recipient. In his address of presentation, Mr. Lof said, in part:

"On the list of illustrious names of great men that have contributed most to the progress of science we find many Swedish ones,—such as Berzelius, Schele, Polhem, Linnæ, Nobel and Ericsson. Ericsson lived in what we call the age of steam.

"Today, I dare say, we are truly living in the age of chemistry with its closely allied branch, electrochemistry. Among the great men who have contributed the most to this field we find one of the greatest living scientists of today, a man whose name is known far and wide and whose researches have resulted in one of the most important contributions to the advancement of science.

"It is this man whom we have unanimously chosen as the first recipient of the John Ericsson medal—the father of electrochemistry — Dr. Svante Arrhenius.

"It is but natural that numerous honors should have been bestowed on this distinguished scientist. In 1903 he received the coveted Nobel prize as a reward for his achievements in the field of chemistry, and since 1905 he has been at the head of the Nobel Physical Institute.

A Great Scientist

"Doctor Arrhenius by his work has strengthened the foundation of the chemical knowledge upon which rests so many of our present-day industries. He succeeded in establishing on a firm basis a general theory of the relations of the electrolytic phenomena to the chemical and physical properties of substances, which is now universally accepted by the scientific world. His work and accomplishments have, however, not been confined alone to this field of the infinitely small. His conceptions gradually expanded and equally interesting are his studies of the infinitely large as so eminently brought out in one of his many books, the 'Destinies of the Stars.'

"It is our great pleasure and honor to be able to award this first impression of the John Ericsson medal to Doctor Arrhenius on the day when we have paid such national honors to the memory of his illustrious countryman."

Among those present were His Excellency Oscar Von Sydow, Governor of Gothenburg and Bohns and former Premier of Sweden, representing the Crown Prince of Sweden; Rear Admiral John D. Beuret, representing the Secretary of the Navy; Albin G. Witting, delegate of the Swedish Engineering Society of Chicago, and Representative Carl R. Chindblom, of Illinois.

Power Permit For Tennessee-Washington Plant For Mines

The Federal Power Co., of Knoxville Tenn., has applied to the Federal Power Commission for a preliminary permit covering seven proposed developments on the Nolichucky-Toe Rivers near the North Carolina and Tennessee lines.

The primary power to be made available is estimated at 27,800 hp. The applicant proposes, however, to install 72,000 hp. The power is intended for public utility service and for use by the electrochemical industry.

The Royal Development Co. of Leavenworth, Wash., has applied for a preliminary permit covering a project on Phelps Creek in Shelan County, Wash. The power is intended for mining purposes.

Valuable Papers on A.S.M.E. Spring Program

At the spring meeting of the American Society of Mechanical Engineers, to be held in San Francisco June 28 to July 1, three papers of special interest to power engineers will be presented.

"Aspects of Steam Power in Relation to a Hydro Supply" will be read by A. H. Markwart. N. F. Funk will give a study on "Comparative Performance of Air Preheaters," and M. K. Bryan will offer for consideration, "Selecting a Power and Heat Supply for Industrial Plants."

Power Company Pushes Oregon River Development

The Portland Electric Power Co., of Portland, Ore., has applied to the Federal Power Commission for an amendment to its license which will allow it to take up the second stage of the development on the main fork of the Clackamas River in Clackamas County, Ore. A tunnel 22,000 ft. long will carry the water into the Oak Grove reservoir. An additional 37,500-kw. unit is to be installed in the Oak Grove power house.

Germany Gathers Statistics on Current Breakdowns

Statistics of great value have been prepared by the Berlin Municipal Electricity Works and the Electro Works, the great long-distance transmission works which supply all central Germany, on the extent to which disturbances of the current supply were experienced in 1925.

There were in all 168 cases of major or minor disturbances. Of these 37 were major and 131 minor cases—quite a fair record. One-half of the major cases were due to the Electro Works and of the minor cases 36. The average duration of stoppage was less than fifteen minutes, and the aggregate loss in kilowatt-hours supplied was only 0.03 per cent.

Australian Plant to Serve Coal Mines and Port

An expenditure of about $1,054,000 will be made in erecting a power station at Collie, Western Australia, Assistant Trade Commissioner Julian B. Foster, Melbourne, reports to the Department of Commerce. Energy will thus be available in the port of Bunbury and for use at the coal mines. It is stated that fertilizer works and a large refrigerating plant also are to erected at Collie.

Fresh Air and Ventilation by C.-E.A. Winslow, Professor of Health, Yale School of Medicine. Published by E. P. Dutton & Co. 681 Fifth Ave., New York City. 5x7¾, cloth. 182 pages. Price $2. The aim of the author in writing this book was to present in broad outlines the modern conception of what good ventilation is, and how we can secure it under varying conditions in the light of recent researches, particularly those of the New York State Commission on Ventilation.

E. D. Adams Donates $100,000 to Engineering Foundation

The quarterly meeting of the Engineering Foundation was held on May 19, members and guests gathering for dinner at the Union League Club, New York. Edward Dean Adams, John Fritz medalist 1926, was guest of honor.

On behalf of the endowment committee W. L. Saunders announced that a contribution of $100,000 has been made to the Foundation by Mr. Adams, and in response to an appropriate resolution Mr. Adams was elected an honorary member for life in recognition of his service as vice-chairman of Engineering Foundation for the last ten years.

Financial assistance was granted to two research projects requested by the American Institute of Mining and Metallurgical Engineers and the American Institute of Electrical Engineers. The sum of $4,000 a year for three years was granted for research in blast-furnace slags by Prof. R. S. McCaffery, University of Wisconsin. The sum of $5,000 a year for two years was granted for research in electrical insulation by Prof. J. B. Whitehead, Johns Hopkins University.

Addresses were made by Dr. John A. Mathews, president of the Crucible Steel Company of America, on "Present Tendencies in Engineering Materials," and by Prof. Richard S. McCaffery, on "Research in Iron Blast Furnace Slags."

Mr. Saunders also announced that United Engineering Society had first-hand knowledge of four wills of living persons containing bequests for Engineering Foundation, of unknown amounts.

Personal Mention

D. B. Worth has been appointed service manager for the Electro-Motive Co., Keith Building, Cleveland, Ohio.

H. C. L. Miller, Jr., is now with the Power Specialty Co., 111 Broadway, New York City.

Roland H. Lamb is now district manager for the Lynn & Emrich Co., manufacturers of the Huber stoker at Baltimore, Md.

Sydney B. Paine, for more than thirty years manager of the mill power division of the industrial department of the General Electric Co., has retired.

Albert B. Williams announces that he is now connected with the Consolidated Gas, Electric Light & Power Co. in the industrial fuel department.

F. W. Utz announces that he has left the Pennsylvania Power & Light Co., Allentown, Pa., to become associated with Gannett, Sedye & Fleming, Inc., Harrisburg, Pa.

Calvin W. Rice, Secretary of the A.S.M.E. has received the degree of Doctor of Engineering from the Technische Hochschule, of Darmstadt, Germany. As Honorary Secretary of the Museum of Peaceful Arts, Doctor Rice is visiting technical and industrial museums in Europe.

NEW PUBLICATIONS

Corrosion—Causes and Prevention—An Engineering Problem. By Frank N. Speller, D. Ss., Ddirector of Metallurgical Department, National Tube Co. Published by the McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York City, 1926. Cloth; 6x9 in.; 621 pages, 125 illustrations; 43 tables; bibliography of corrosion. Price, $6.

For some time there has been urgent need for a comprehensive book on corrosion, crystallizing the best and latest thought on the subject. The money losses due to corrosion are enormous, as has frequently been pointed out, and steps to reduce these losses are an immediate economic necessity in almost every industry. There is probably no man in the country better equipped to write a well-rounded book on the subject than Mr. Speller. His book is well designed to meet the needs of all classes of readers interested in corrosion.

The body of the book is divided into two parts, the first dealing with general principles and the second with preventive measures. Under the first heading the seven chapters cover the following subjects: Introductory outline of the corrosion problem; nature and mechanism of corrosion; influence of methods of manufacture and of internal and external factors; corrosion testing; relative corrosion of ferrous metals. The following subjects come under the head of preventive measures: Prevention of corrosion in the atmosphere, in closed water systems (by removal of dissolved gases), in high-pressure steam plants and in steam and hot-water heating systems; chemical corrosion; prevention of corrosion underground; stray-current electrolysis; classified list of selected reference on the corrosion of ferrous metals.

At the end of the book is an apendix covering such matters as hydrogen-iron concentration, calculation of corrosion in inches per year, etc. There is also an extensive bibliography of books and articles on corrosion, a subject index and an author's index.

A Bibliography on Research. Selected articles from the technical press of 1923, 1924, 1925. Published by the National Research Council, Division of Engineering and Industrial Research, 29 West 39th St., New York City. Paper; 46 pages.

The primary purpose in compiling this bibliography was an effort on the part of the engineering division of the Council to feel the pulse of industry and to maintain close contact with its research. The effective use of this service has proved a valuable aid in carrying out one of the major functions of the division, namely, the promotion of scientific and industrial research. This bibliography is the most complete survey of current articles on research yet published. There are 46 subjects of general research listed, with the name, volume and page of the periodical, covering the outstanding research activities in specific industries. Copies may be obtained free from Maurice Holland, director, at the above address.

Business Notes

Carew Sheldon is now located at the Hauto Steam Electric Station of the Pennsylvania Power & Light Co., Nesquehoning, Pa.

Clifton Reeves Co., consulting and operating industrial engineers, formerly at 150 Broadway, New York City, announce removal to 341 Madison Avenue.

R. H. Beaumont Co., coal and ash handling equipment manufacturers, announce the opening of a Western branch office at 1544 Strauss Building, 310 South Michigan Ave., Chicago.

The Standard Asbestos & Cork Co., 541 South Troost St., Tulsa, Okla., is now distributor of the Adamant firebrick cement, a product of the Botfield Refractories Co., of Philadelphia.

James G. Robertson, founder of J. G. Robertson & Co., power-plant manufacturers, of St. Paul, Minn., died recently at his home. He came to St. Paul in 1885 and headed the company which bore his name for more than 35 years.

Paul W. Koch & Co., 15 South Wells St., Chicago, are now marketing a new "Jiffy" Labor-Saver, a pipe bender vise in which ½ and ¾ in. conduit may be cut, threaded and bent without removing from the vise. As a vise it will take conduit up to 2 in., but construction of the vise is much heavier than standard 2-in. size.

Rockland Light & Power Co., Nyack, N. Y., formed by consolidation of Rockland Light & Power, Orange County Public Service Co., Inc., and Catskill Power Corp., has been chartered at Albany with a capital of $26,000,000. Charles H. Tenney, 35 State St., Springfield, Mass., D. Edgar Manson, 200 Devonshire St., Boston, Mass., and Alexander S. Burns, Jr., Spring Valley, N. Y., are directors and subscribers.

Trade Catalogs

Turbine Drive for Paper Machines— The Terry Steam Turbine Co., Hartford, Conn. Bulletin describing the new Terry Paper-Machine Drive consisting of a specially designed turbine with herringbone reduction gears of the self-contained type. Applications to rope-drive system, Marshall system, etc., are illustrated.

Pumps—Dean Hill Pump Co., Anderson, Ind. Reciprocating deep well pump heads, as a specialized product of this concern, are treated in this illustrated bulletin, which contains a complete listing of specifications and a table of maximum capacities. Bulletin No. 1501. Horizontal single suction centrifugal pumps are described in detail with many figures and tables of styles and dimensions. Bulletin No. 203.

Compressed Air Trade Standards, adopted by The Compressed Air Society, 2nd Edition, 1926, Secretary C. H. Rohrbach, 90 West St., New York City. This pamphlet embodies the result of the study and research on the part of the executives and engineers associated with the members of this society and embraces the nomenclature and terminology relating to air compressors, an explanation of capacities and pressure, instructions for the installation and care of, with illustrations of devices for cleaning the intake air, recommendations of the lubrication and the cleaning of the receiver piping.

Coming Conventions

American Boiler Manufacturers Association. D. W. Glanzer, 840 Rockefeller Bldg., Cleveland, Ohio. Annual convention at Homestead, Hot Springs, Va., June 1-2.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Regional meeting at Niagara Falls, May 26-28. Annual convention at White Sulphur Springs, W. Va., June 21-25.

American Order of Steam Engineers. W. S. Wetzler, 758 N. 44th St., Philadelphia, Pa. Annual convention at Moose Hall, Philadelphia, June 7-11.

American Society for Testing Materials. C. L. Warwick, 1315 Spruce St., Philadelphia, Pa. Convention at Haddon Hall, Atlantic City, N. J., June 21-25.

American Society of Mechanical Engineers. Calvin W. Rice, 29 West 39th St., New York City. Spring convention at San Francisco, Calif., June 28-30.

American Water Works Association. W. M. Niesley, Assistant to Sec., 170 Broadway, New York City. Annual convention at Hotel Statler, Buffalo, N. Y., June 7-12.

Association of Iron & Steel Electrical Engineers. John F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Exposition and convention at Hotel Sherman, Chicago, Ill., June 7-10.

Canadian Association of Stationary Engineers. G. A. Brown, secretary, Major St., Toronto, Ontario. Convention and exposition, London, Ontario, June 29.

National Association of Stationary Engineers. F. W. Raven, 417 South Dearborn St., Chicago, Ill. Convention at Atlantic City, begins Sept. 14. Erroneously announced as Sept. 6-11. Annual conventions and exhibitions of state associations are scheduled for the following dates:

Illinois State Association. O. Jacobsen, 837, Lakeside, Place, Chicago. Convention at Decatur, Ill., June 2-4; **New England States Association,** Freeman L. Tyler, 32 Briggs St., Taunton, Mass. Convention at New Bedford, Mass., June 16-19; **Ohio State Association.** T. S. Garrett, 2622 E. Second St., Dayton, Ohio. Convention at Newark, Ohio, June 17-19; **Connecticut State Association,** George F. Klopfer, 30 East Pearl St., New Haven, Conn., Convention at Norwich, Conn., June 25-26; **Wisconsin State Association,** R. L. Scott, Eau Claire, Wis. Convention at Milwaukee, Aug. 3-6; **Minnesota State Association,** C. A. Nelson, 800 22nd Ave., N. E. Minneapolis, Minn. Convention at Rochester, Minn., Aug. 4-6; **New Jersey State Association,** S. G. Dalrymple, 111 Hutton St., Jersey City, Convention at Atlantic City, Sept. 12; **Pennsylvania State Association,** Frank J. McCarron, 3647 North 11th St., Philadelphia, Convention at Philadelphia, Sept. 12-13.

National District Heating Association. D. L. Gaskill, Greenville, Ohio. Convention at Niagara Hotel, Niagara Falls, June 1-4.

Universal Craftsmen Council of Engineers. 24th convention and exhibit Milwaukee Auditorium, Milwaukee, Aug. 3-7.

Water Softener—Graver Corp., East Chicago, Ind. Bulletin No. 509, just published, describes the Graver Zeolite Water Softener, which uses the downflow method of softening with a natural zeolite mineral supported by a strainer plate of special design. The bulletin is profusely illustrated.

Asbestos Lumber and Other Products—Asbestos Shingle, Slate and Sheathing Co., Ambler, Pa. Among the products described in a new booklet, "Ambler Asbestos Products," is Ebonized Asbestos Lumber, a material recently developed for use in control boards and panels. The booklet contains data on the physical and electrical characteristics of various grades and thicknesses of asbestos lumber.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run except Pittsburgh gas slack:

Bituminous Net Tons	Market Quoting	May 24 1926
Pool 1	New York	$2.50@$2.75
Smokeless	Boston	1.70
Clearfield	Boston	1.65@ 2.00
Somerset	Boston	1.75@ 2.10
Kanawha	Columbus	1.40@ 1.75
Hocking	Columbus	1.40@ 1.70
Pittsburgh	Pittsburgh	1.75@ 1.90
Pittsburgh gas slack	Pittsburgh	1.35@ 1.40
Franklin, Ill.	Chicago	2.35@ 2.50
Central, Ill.	Chicago	2.00@ 2.15
Ind. 4th Vein	Chicago	2.10@ 2.25
West Ky.	Louisville	1.00@ 1.40
S. E. Ky.	Louisville	1.35@ 1.65
Big Seam	Birmingham	1.75@ 2.25
Anthracite Gross Tons		
Buckwheat No. 1	New York	1.70@ 3.50
Buckwheat No. 1	Philadelphia	2.00@ 2.75
Birdseye	New York	1.30@ 2.00

FUEL OIL

New York—May 27, light oil, tank-car lots; 28@34 deg. Baumé, 5¾c. per gal.; 36@40 deg., 6¼c. per gal. f.o.b. Bayonne, N. J.

St. Louis—May 18, tank-car lots, f.o.b. St. Louis; 24@26 deg., $2.10 per bbl.; 26@28 deg., $2.15 per bbl.; 28@30 deg., $2.20 per bbl.; 30@32 deg., $2.25 per bbl.; 32@36 deg., gas oil, 5.9c. per gal.; 38@40 deg., 6.5c. per gal.

Pittsburgh—May 18, f.o.b. local refinery; 30@34 deg., fuel oil, 6¾c. per gal.; 36@40 deg., fuel oil, 7¼c. per gal.

Dallas—May 22, f.o.b. local refinery 26@30 deg., $1.70 per bbl.

Philadelphia—May 26, 27@30 deg., $2.31@$2.37 per bbl.; 18@22 deg., $1.93@$1.99; 13@19 deg., $1.68@$1.74 per bbl.

Cincinnati — May 24, tank-car lots f.o.b. local refinery, 24@26 deg. Baumé, 6¼c. per gal.; 26@30 deg., 6⅝c. per gal.; 30@32 deg., 7c. per gal.

Chicago—May 17, tank-car lots f.o.b. Oklahoma, freight to Chicago, 92c. per bbl.; 24@26 deg., $1.30@$1.35 per bbl.; 26@30 deg., $1.40; 30@32 deg., $1.60@$1.65.

Boston—May 24, tank-car lots, f.o.b. 12@14 deg. Baumé, 4.42c. per gal.; 28@32 deg., 5¾c. per gal.

New Plant Construction

Ark., Smackover—Simms Oil Co., Magnolia Bldg., Dallas, Tex., will build an oil refinery including boiler plants, etc., near here. Work will be done under the supervision of F. Gardner, c/o owner, Engr.

Calif., Los Angeles—California Club is having preliminary plans prepared for the construction of a 10 to 12 story office and club building on Hope St. R. D. Farquhar, Security Bldg., Los Angeles, is architect, and G. W. Kelham, Sharon Bldg., San Francisco, is associate architect.

Calif., Sacramento—City plans an election to vote $976,400 bonds for extensions to sewage system including pumping equipment, etc. A. J. Wagner, is engineer.

Calif., Santa Ana—Orange County Water Dist., plans improvements to waterworks including deep well pump, booster pump and motors, etc. W. K. Hillyard, is engineer.

• **Conn., New Haven**—M. Koury, 1430 Dixwell Ave., will build an 8 story office building, including vapor heating and refrigeration systems, electric elevators, etc., at Grove and Church Sts., by day labor. Estimated cost $500,000.

Ill., Chicago—City, A. A. Sprague, Comr. of Public Works, will soon receive bids for complete electrical equipment for bridge over the Calumet River. Estimated cost $75,000.

Ill., Chicago—Davis Hotel Co., 827 Wilson Ave., awarded contract for the construction of a 14 story hotel at Walton Place and North Michigan Ave. to Avery Brundage, 110 South Dearborn St. Estimated cost $3,000,000.

Ill., Chicago — I. M. Sevin, and H. L. Solomon, 140 North Dearborn St., will soon receive bids for the construction of a 12 story apartment including central refrigeration plant, vacuum heating system, etc., at Surf St. and Sheridan Road. Estimated cost $2,500,000. Lowenberg & Lowenberg, 111 West Monroe St., are architects.

Ia., Maquoketa—Greene Island D. D. No. 1 will receive bids about July 10 for the construction of a pumping station, drainage ditches, etc. Estimated cost $78,000. Central States Engineering Co., Muscatine, is engineer.

Md., Baltimore—Civic Center Realty Co., I. Silberstein, Pres., 404 St. Paul St., is having plans prepared for the construction of an 18 story office building at Calvert and Lexington Sts. Estimated cost $1,250,000. L. R. White, Hearst Tower, is architect.

Md., Hagerstown—City rejected bids for the construction of a pumping station and filtration plant. G. L. Bean, Abbott Bldg., Philadelphia, Pa., is engineer.

Mass., Boston—The Embassy Inc., J. S. Draper, 209 Summer St., awarded contract for the construction of an 11 story apartment at 390 Beacon St. to W. H. Whitcomb Construction Co., 6 Beacon St. Estimated cost $1,250,000.

Mass., New Bedford — Pocahontas Fuel Co., Inc., is receiving bids for the construction of a boiler house. Estimated cost $40,000. H. S. Adams, 1 Court St., Boston, is engineer.

Mass., South Boston (Boston P. O.) — Boston Elevated Railway Co., Park Square Bldg., Boston, will build an addition to power house on East First St., here, by day labor. Estimated cost $130,000. Dwight P. Robinson Co., 125 East 46th St., New York, N. Y., is engineer.

Mich., Detroit—A. N. Collins, 38 Martin Pl., is having plans prepared for the construction of a 21 story hotel including steam heating system. Estimated cost $1,500,000. J. Kasurin, 502 Empire Bldg., is architect.

Mich., Detroit — G. J. Hilsendgen, 108 Lochmoor Ave., awarded contract for the construction of a 13 story apartment at John R. St. to Martin-Krausman Co., 955 East Jefferson Ave. Estimated cost $1,200,000. Steam heating system will be installed.

Mich., Flint—City, F. D. King, Clk., will receive bids until June 11 for Cont. S. D. 3, construction of Third Ave. pumping station including heating plant, power switchboard, etc.

Mich., Niles—The City Ice & Fuel Co., c/o E. C. Balzhizer, V. Pres., 6611 Euclid Ave., Cleveland, O., is having preliminary plans prepared for the construction of an ice plant. Estimated cost $200,000. W. A. Schmidt, 3320 Jefferson Ave., Cincinnati, O., is architect. C. C. Coneby, 3320 Jefferson Ave., Cincinnati, O., is engineer. Complete refrigerating equipment will be installed.

Minn., Minneapolis—Calhoun Beach Holding Co., H. S. Goldie, 929 Plymouth Bldg., plans the construction of a 6 story hotel on West Lake St. and Dean Blvd. Estimated cost $500,000. Magney & Tusler, 126 South 9th St., are architects.

Minn., St. Paul—Arcade Investment Co., H. Lowry, Pres., 600 Temple Court, Minneapolis, awarded contract for the construction of a 9 story hotel at Fourth and Wabasha Sts., here, to G. J. Grand Construction Co., 904 Exchange Bank Bldg., St. Paul. $1,000,000.

Minn., St. Paul—Armstrong & White, 200 East Erie St., Chicago, Ill., Archts., are preparing plans for the construction of a hotel, here. Estimated cost $1,200,000. Owner's name withheld.

Miss., Woodville — Town, J. A. Massay, Mgr. Light and Water Plant, will receive bids until June 8 for new electrical equipment for light plant.

Mo., Kansas City — J. C. Nichols Co., Commerce Bldg., has acquired a 15 acre site and plans the construction of apartment buildings at 49th St., Ward Parkway, Main St. and Wornall Road. Estimated cost $5,000,000 to $7,000,000. Wilkinson & Crans, Interstate Bldg., are architects.

Mo., Kansas City — St. Marys Hospital 28th and Main St., awarded contract for the construction of a boiler room and steam laundry to George P. Reintjes Co., 314 Interstate Bldg. Estimated cost $60,000.

Mo., St. Louis—American Pharmaceutical Assn., c/o E. S. Sater, University of Minnesota, is having preliminary plans prepared for the construction of a 10 story office building. Estimated cost $1,000,000.

Mo., St. Louis—F. L. Fisher, 7509 South Broadway, is in the market for a 10 to 40 hp., 3 ph., 220 v. electric motor.

Mo., St. Louis—Local Syndicate, c/o E. Thompson, Pierce Bldg., awarded contract for the construction of an 8 story hotel at Delmar St. and Euclid Ave. to Widmer Engineering Co., Laclede Gas Bldg. Estimated cost $1,300,000.

Mo., St. Louis — C. A. Moreno, 1228 Syndicate Trust Bldg., is in the market for a 3 or 4 in. steam suction pump complete.

N. Y., New York—Bing & Bing, 119 West 40th St., will build two 15 story apartments on West End Ave. Estimated cost $1,000,000 each. E. Roth, 110 West 40th St., is architect. Work will be done by separate contracts under the owner's supervision.

N. Y., New York — Fred G. Ley & Co. Inc., 19 West 44th St., will build a 13 story apartment at 5th Ave. and 18th St. Private plans. Work will be done by separate contracts. Owner is general contractor.

N. Y., New York—B. Winter, 250 Park Ave., plans the construction of a 30 story apartment at 52nd St. and 5th Ave. Springsteen & Goldhammer, 32 Union Square, are architects.

N. C., Greensboro—Greensboro Bank & Trust Co., W. F. Hope, V. Pres., awarded contract for the construction of a 12 story bank and office building on South Elm St., to Angle & Blackford. $900,000.

O., Bowling Green — Bd. of Trustees, Bowling Green State Normal School, H. J. Johnston, Secy., will receive bids until June 23 for two 356 hp. boilers for power house.

O., Cincinnati — County Commissioners, Hamilton County, will receive bids until June 8, for the construction of sanitary sewer 11, Dist. 3, including pumping station and equipment complete in Beechwood and Edgemont sub-divisions. Estimated cost $108,204. L. C. Boyatt, Court House, is engineer.

O., Cleveland—Sanitary Dist., Washington County, H. H. Hood, Pres. and Gen. Mgr., 6204 Central Ave., is in the market for a 200 hp. boiler and 60 hp. engine and water heater for proposed addition to laundry.

O., Columbus — Dept. of Waterworks, C. B. Hoover, Supt., City Hall, is in the market for coal and ash conveyor for pumping station at Dublin Pike northwest of here. Estimated cost $25,000.

O., Mansfield — Richland Hotel Co. awarded contract for the construction of a 7 story hotel to Van Blarcom Co., National City Bldg., Cleveland. Estimated cost $600,000.

Pa., Danville—Bd. of Trustees, Danville State Hospital, F. M. Sprout, Secy., will receive bids until June 10 for furnishing and installing four boilers, traveling grate stokers and combustion control, ash grates, etc., in power house.

Pa., Lewistown — Viscose Co., Marcus Hook, will soon award contract for the construction of addition to power house on Juniata River here. Ballinger Co., 12th and Chestnut Sts., Philadelphia, is architect and engineer.

Pa., Philadelphia—Tremont Realty Co., Adams St. and Powder Mill Rd. awarded contract for the construction of a boiler house at Winghocking St. and West Adams Ave., to H. D. Best Co., 949 Broadway, New York, N. Y. Estimated cost $13,500.

Tex., Brackettville—Texas Central Power Co., Frost Bldg., San Antonio, has acquired electric and ice plants and plans improvements including new engine and other equipment for the electric plant, also a 15 ton additional unit to ice plant, etc., here. Estimated cost $60,000. Private plans.

Tex., Galveston — High Grade Packing Co., c/o J. Tramont, 2627 Ave. D., is having plans prepared for the construction of a 2 story packing house including refrigeration and steam plants, etc. Estimated cost $50,000. Stowe & Stowe, 311½ 22nd St., are architects.

Tex., Moulton—Texas Central Power Co., Frost Bldg., San Antonio, has acquired electric and ice plants and plans improvements to increase the capacity here. Estimated cost $50,000. New machinery will be required.

Tex., Olmito — Al. Parker Securities Co., Brownsville, will soon receive bids for the construction of an electric light plant here. Estimated cost $40,000. Private plans. New engines, dynamos, etc., will be required.

Tex., Waco—O. H. Cross, plans the construction of a 12 story hotel at Fifth and Franklin Sts. Estimated cost $700,000. Architect not selected. C. M. Hildon, Hildon Hotel and H. Sigel, Waldorf Hotel, Dallas, are lessees.

Tex., Wichita Falls—City plans an election June 12 (extended date) to vote $1,200,000 bonds for improvements to waterworks including pumping plant, filter and softening plants, etc., at Lake Wichita. T. U. Taylor, Austin, is consulting engineer. W. E. McBroom is secretary.

Tex., Wichita Falls—Peoples Ice Co., c/o A. C. Yayzor, Mgr., subsidiary of Commonwealth Utilities Corp., St. Louis, Mo., is having surveys made for the construction of a cold storage plant here. Estimated cost $100,000. Private plans. Complete equipment will be required.

Wis., Cedarburg — Federal Silver Fox Farms Co., J. F. Nieman, Pres., Thiensville, plans the construction of a refrigeration plant here. Estimated cost $50,000.

Ont., Hamilton — Dominion Power & Transportation Co., G. E. Waller, Mgr., King and Catharine St., plans the construction of a power station. Estimated cost $50,000.

Sask., Regina — Ross & MacDonald, 1 Belmont St., Montreal, Que., Archts., will receive bids until June 8 for the construction of a 9 story hotel here, for Canadian Pacific Ry., Montreal, Que. Estimated cost $2,500,000.